STUDY ON INDUSTRY

ANALYSIS OF POLICIES AND MEASURES

(STUIND)

STUDY ON INDUSTRY ANALYSIS OF POLICIES AND MEASURES (STUIND)

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INTRODUCTION

"Sustainability is not just about adopting the latest energy-efficient technologies or turning to renewable sources of power. Sustainability is the responsibility of every individual every day. It is about changing our behaviour and mindset to reduce power and water consumption, thereby helping to control emissions and pollution levels"

Joe Kaeser

The Industry sector can be analyzed from two different aspects. On the one hand, it plays a very important role in the development of the economy, through its added value in the Gross Domestic Product (GDP) and the number of employees. On the other hand, the industry is one of the largest energy consumers, and thus one of the sectors with the largest emissions of greenhouse gases (GHG), but also emissions of particles with a negative impact on ambient air quality. At the same time, the implementation of the measures to increase energy efficiency and mitigate climate change suggests that they can be more easily applied in the households and commercial sector than in the transport and industry sectors. This is especially the case with developing countries. The small number of measures in the industry sector is a result of the widespread thinking that energy efficiency in industry is related only to the manufacturing process, which is accompanied by large investments and risks and thus forgetting the great potential for reducing energy consumption which is not directly related to the process itself. In other words, it is forgotten that there are "soft measures" that do not require investments or require a very small amount of investments, that can have great potential for reducing energy consumption.

Greenhouse gas emissions directly related to the Industry, according to the IPCC methodology, are reported in three sectors:

- Energy (category Manufacturing and Construction Industry), where emissions from the use of **energy** in the Industry are reported,
- Industrial Processes and Product Use of (IPPU), where emissions associated with **the processes** in the Industry are reported,
- Waste (category Industrial Waste, Wastewater Treatment and Discharge of the Industry), where emissions from **the Industry waste** is reported.

Worldwide[1], the Industry sector accounts for about 20% of the total GHG emissions, while in Macedonia, this percentage is around 17% in 2016. Most of the GHG emissions from the Industry are from fuel combustion, which in Macedonia participates with about 10% in the total GHG emissions. Worldwide, the Industry is responsible for about 29% of the final energy consumption and 23% of the total number of employees. At the European Union (EU) level, the share of industry in the final energy consumption is 22%, which is exactly the same as in Macedonia in 2018. According to the IFC study[2], which assesses opportunities for reducing energy consumption in Industry and ranks them according to the payback period, the technical potential for reducing energy consumption depends on the type of Industry and ranges between 20% - 30%.

1 https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

2 https://ec.europa.eu/energy/sites/ener/files/documents/151201%20DG%20ENER%20Industrial%20EE%20study%20-%20final%20report_clean_stc.pdf

According to the EUROSTAT methodology, which is also implemented by the State Statistical Office (SSO), the following sectors are included under Industry (according to the Nomenclature of Economic Activities - NACE):

- Mining and quarrying
- Manufacturing and Construction
- Construction

In the following text, the use of the term "Industry" in this study corresponds to these three sectors.

Reducing energy consumption in the Industry sector, the introduction of renewable energy sources, the possibility of using the Industry for demand response and the improved waste management can contribute towards achieving the targets set in terms of the five dimensions defined by the European Energy Union, as well as in the Strategy for Energy Development in Macedonia until 2040:

- Energy Efficiency
- Decarbonization
- Energy Security
- Internal Energy Markets
- Research, Innovations and Competitiveness

AIM OF THE STUDY

Having in mind that the Industry in Macedonia continuously increases its share in GDP (21% in 2017) and the fact that it employs 30% of the employees in Macedonia, and on the other hand in the final energy consumption participates with about 22% in 2018 and about 17% in GHG emissions in 2016, one of the **main targets** in this study is to propose measures for industrial production growth at reduced energy consumption, which will enable reduction of GHG and local emissions from this sector. Other goals in this study are:

- to make **an overview** of the Industry in Macedonia and its role in the economy, the consumption of energy and in the GHG emissions (this is the first study that integrates all aspects),
- to propose more detailed **measures** to mitigate climate change,
- to determine the **potential** of each measure, as well as the potential for climate change mitigation when implementing all the measures together.

INDUSTRY IN MACEDONIA THROUGH NUMBERS

"Data is not information, information is not knowledge, knowledge is not understanding, understanding is not wisdom"

Clifford Stoll

The sectors in Macedonia, according to the EUROSTAT methodology, which is also implemented by SSO, are divided into divisions according to the Nomenclature of Economic Activities (NACE 2). According to this classification the sectors Mining and quarrying, Manufacturing and Construction have 3, 24 and 3 divisions, correspondingly (Table 1).

Table 1. Classification of the Industry by sectors and divisions according to NACE 2

B MINING AND QUARRYING
07 Mining of metal ores
08 Other mining and quarrying
09 Mining services
C MANUFACTURING
10 Manufacture of food products
11 Manufacture of beverages
12 Manufacture of tobacco products
13 Manufacture of textiles
14 Manufacture of wearing apparel
15 Manufacture of leather and related products
16 Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17 Manufacture of paper and paper products
18 Printing and reproduction of recorded media
19 manufacturing of coke and refined petroleum products
20 Manufacture of chemicals and chemical products
21 Manufacture of basic pharmaceutical product and pharmaceutical preparations
22 Manufacture of rubber and plastic products
23 Manufacture of other non-metallic mineral products
24 Manufacture of basic metals
25 Manufacture of fabricated metal products, except machinery and equipment
26 Manufacture of computer, electronic and optical products
27 Manufacture of electrical equipment
28 Manufacture of machinery and equipment n.e.c.
29 Manufacture of motor vehicles, trailers and semi-trailers
30 Manufacture of other transport equipment
31 Manufacture of furniture
32 Other manufacturing
33 Repair and installation of machinery and equipment

F CONSTRUCTION
41 Construction of buildings
42 Civil engineering
43 Specialized construction activities

On the other hand, according to the energy balance, the consumption in the Industry is divided in ten industry branches and each of them includes one or more NACE divisions (Table 2). In order to consistently present the data from various sources in the Industry, in this study the division according to the energy balance has been applied. Only one change has been made: The Non-ferrous metal industry has been merged with the Iron and steel industry, because for certain data there is no detailed separation by division, and both the Non-ferrous metal industry and the Iron and steel industry include the NACE code 24.

Table 2. Classification of the industry according to the energy balance

Industry branches	НКД
Iron & steel industry	24.1, 24.2, 24.3, 24.51, 24.52
Chemical industry	20, 21
Non-ferrous metal industry	24.4, 24.53, 24.54
Glass, pottery & building mat. industry	23
Ore-extraction industry:	07, 08, 09.9
Food, drink & tobacco industry:	10, 11, 12
Paper and printing:	17, 18
Textile, leather & clothing industry:	13, 14, 15
Engineering & other metal industry:	25, 26, 27, 28, 29, 30
Other industries	16, 41, 42, 43

CONTRIBUTION OF THE INDUSTRY IN THE ECONOMY

The industry in Macedonia is continuously increasing its share in GDP, which in 2017 amounted to 21%. During the period 2011-2017, GDP grew by about 14%, while the value-added of the Industry in GDP grew by 29%. The Other industries (in which Construction is also included) contributes the most (49% in 2017) in total value added of Industry in Macedonia (Figure 1). It is followed by Engineering and other metal industry with about 15%, Food, drink and tobacco industry with 11% and Textile, leather and clothing industry with 10% in 2017. On the other hand, the Iron and steel industry and the Paper and printing industry account for about 2% of the Industry's total value added in 2017. Of the total number of entities that contribute to the added value in GDP, 18% in 2019 belong to the Industry (Mining and quarrying, Manufacturing and Construction on Figure 2).

Figure 1. Value added in GDP by industry

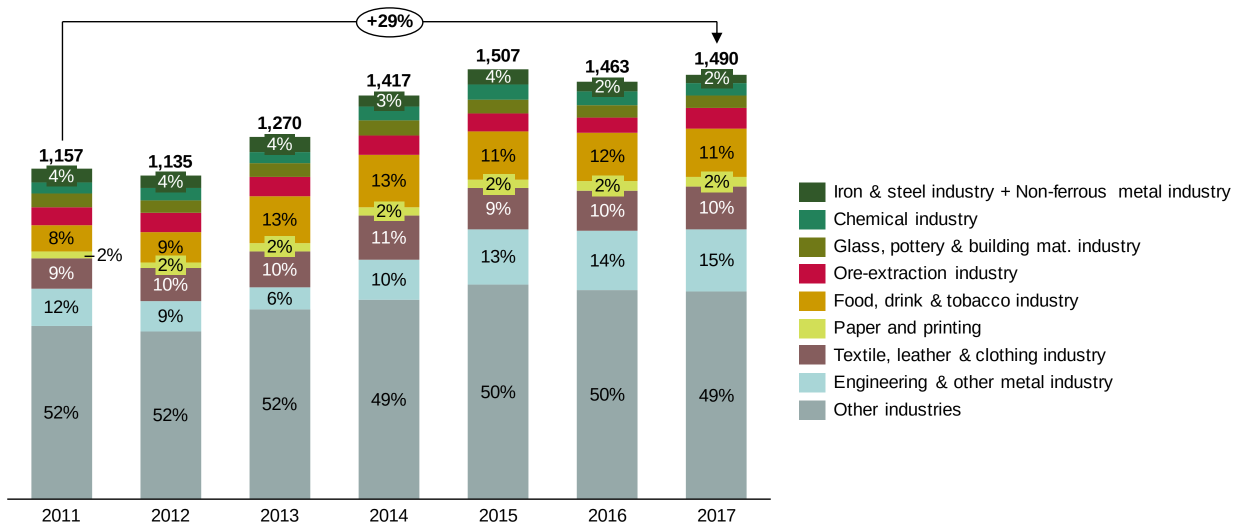
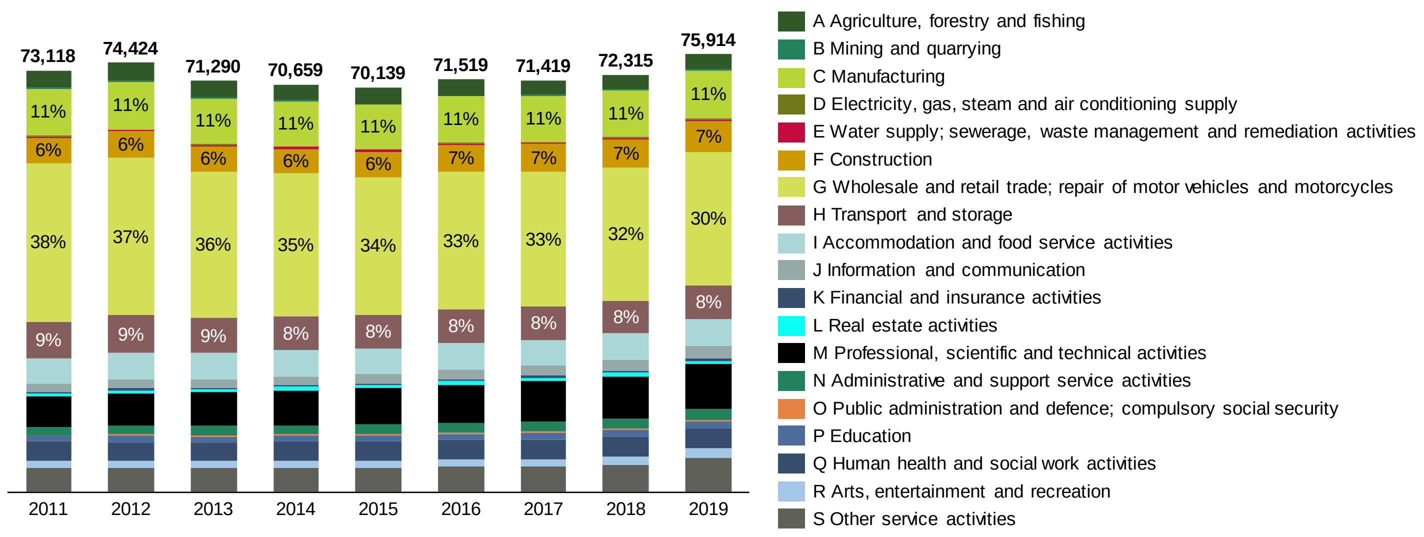


Figure 2. Number of business entities by sectors



The total number of employees in Macedonia in 2018 was approximately 760,000 (40% female), of which about 30% in the Industry (Mining and quarrying, Manufacturing and Construction on Figure 3). Of the total number of employees in the Industry, 36 % are women. The participation of employees in the Industry in the total number of employees is generally constant in the period 2011-2018 year. On the other hand, the SSO regularly conducts a survey of a number of entities according to which it determines the number of employees per division (NACE). According to this survey, which does not cover all entities, especially in the areas of Agriculture, forestry and fishing, the total number of employees is about 567,000 (Figure 4). What is of interest in this study is the number of employees in the Industry. In 2018, 29% of employees are in the Textile, leather and clothing industry, 24% in Other industries, 22% in Engineering and other metal industries and 12% in the Food, drink and tobacco industry (Figure 5). The largest increase in employees is in Engineering and other metal industry, whose share increased from 11% in 2011 to 22% in 2018.

Figure 3. Number of employees by busines sectors

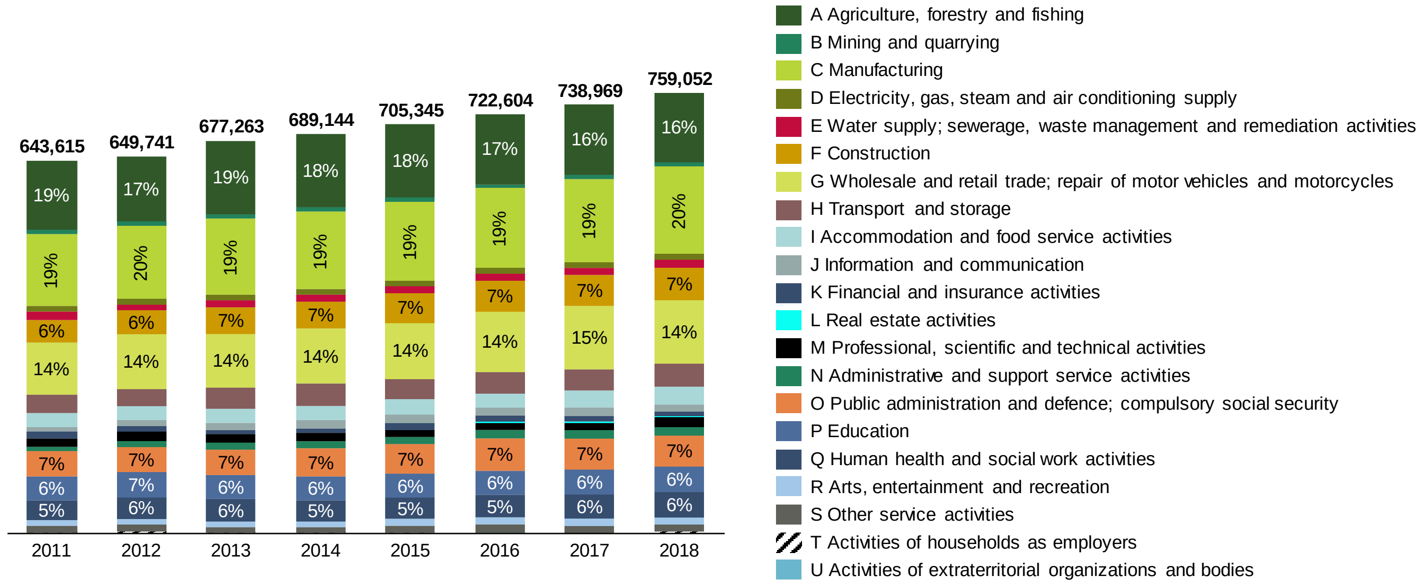


Figure 4. Number of employees by sectors and divisions according to the SSO survey (Number of employees by sectors and divisions)

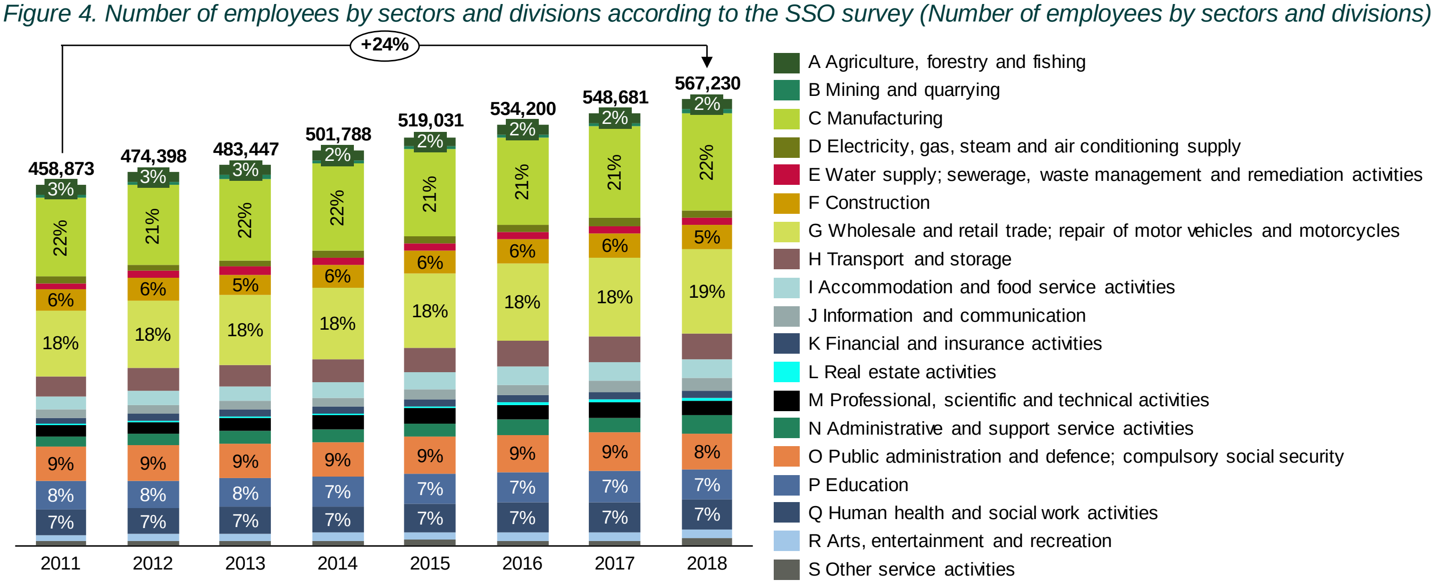
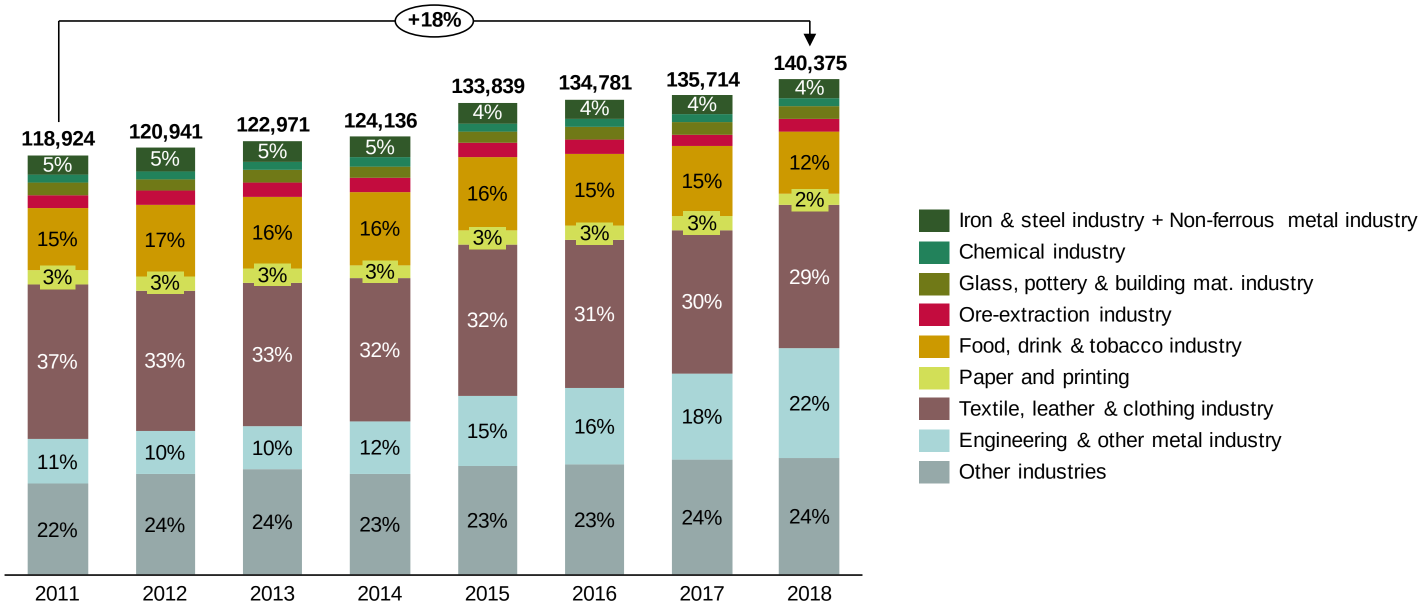


Figure 5. Number of employees (in '000) by industries according to the SSO survey (Number of employees by sectors and divisions)



CONSUMPTION AND ENERGY EFFICIENCY IN THE INDUSTRY

The industry in GDP participates with 21% in 2017 and it significantly contributes to final energy consumption and during the period when the entire Industry worked (before the interventions in terms of meeting environmental standards) it participated with 30% in final energy consumption (Figure 6). In 2018, its share decreased to 22%. Regarding the final consumption by types of industries, the Iron and steel industry has by far the largest share in the whole period and in 2018 it is 44% (Figure 7). On the other hand, the four industries that participate the most in the value-added of the industry in GDP (Other Industries, Engineering and other metal industry, Food, drink and tobacco industry and Textile, leather and clothing industry), in the final energy consumption in 2018 participate with only 22%. The same can be confirmed by the figure for energy intensity of the different types of industries, based on consumption per industrial production growth index (Figure 8). Namely, it is noticeable that the Iron and steel industry has by far the highest energy intensity compared to other industry types.

Figure 6. Final energy consumption by sectors (ktoe)

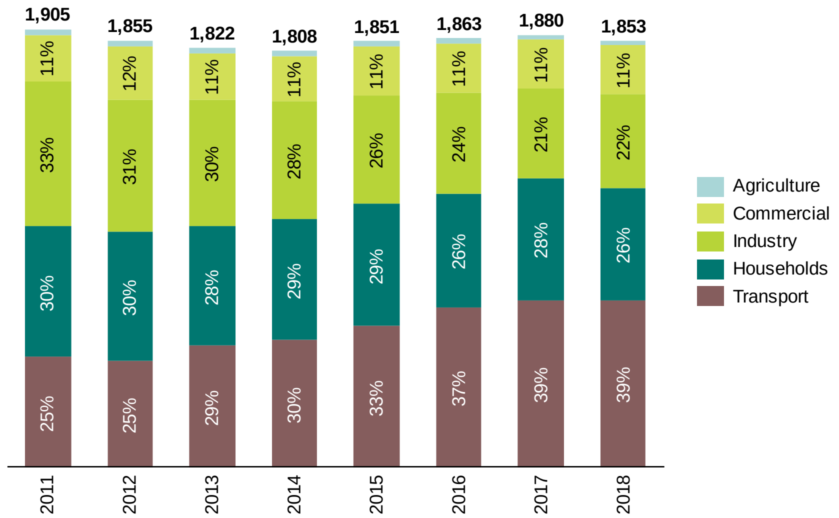


Figure 7. Final energy consumption by fuels by industry branches (ktoe)

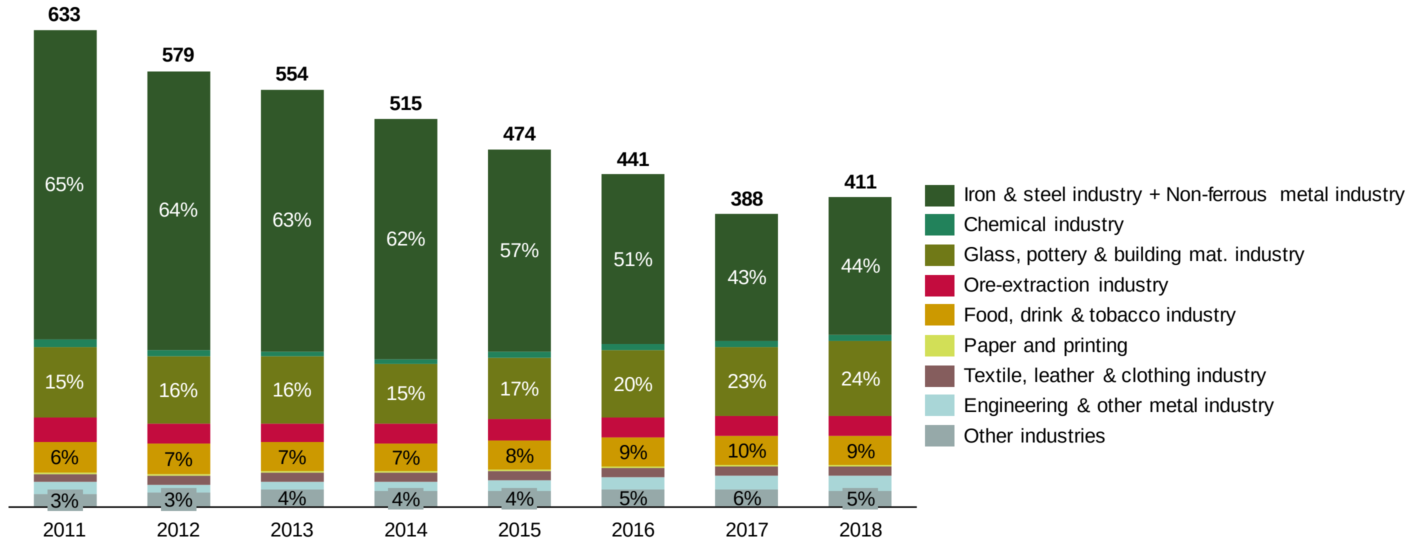
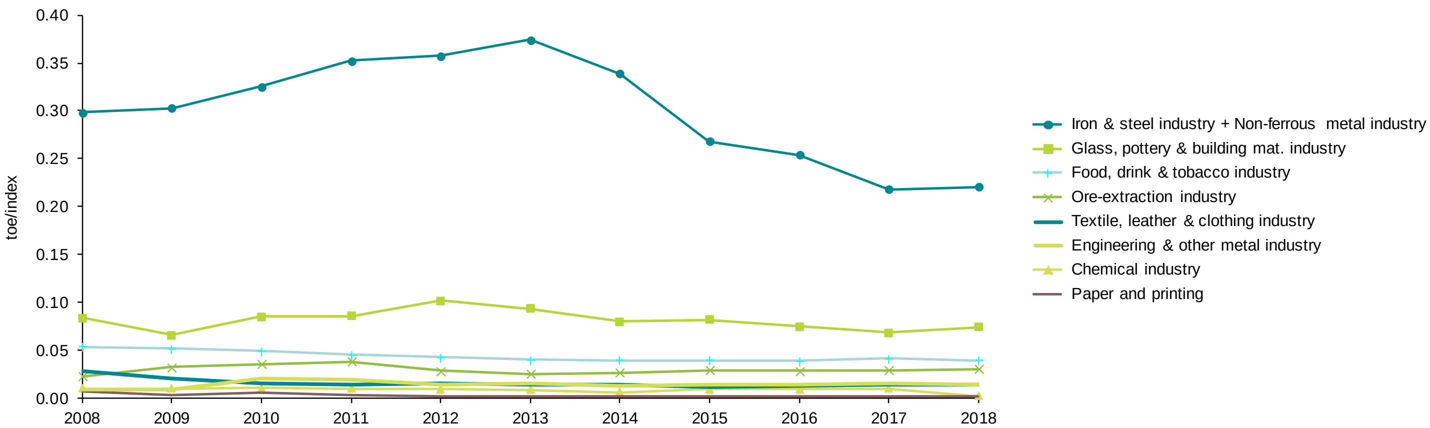
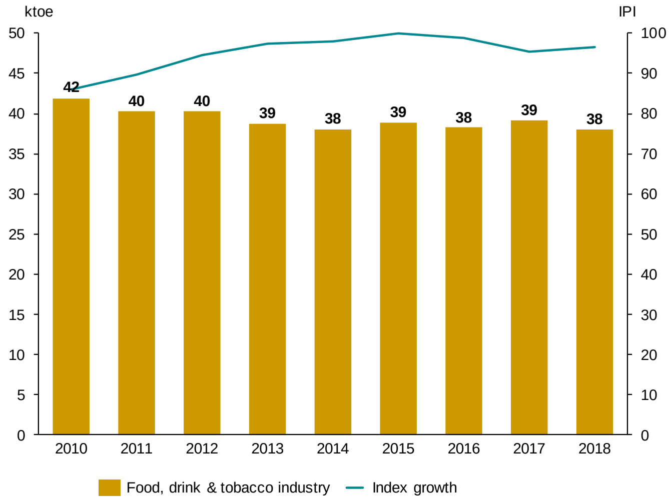


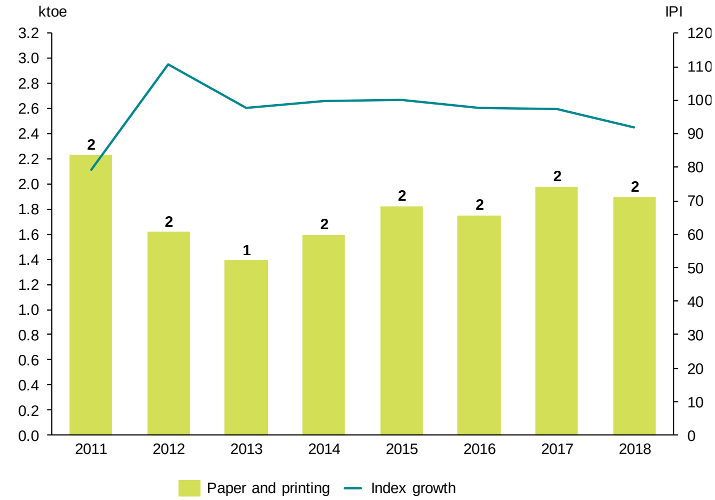
Figure 8. Energy intensity (consumption/industrial production growth index)

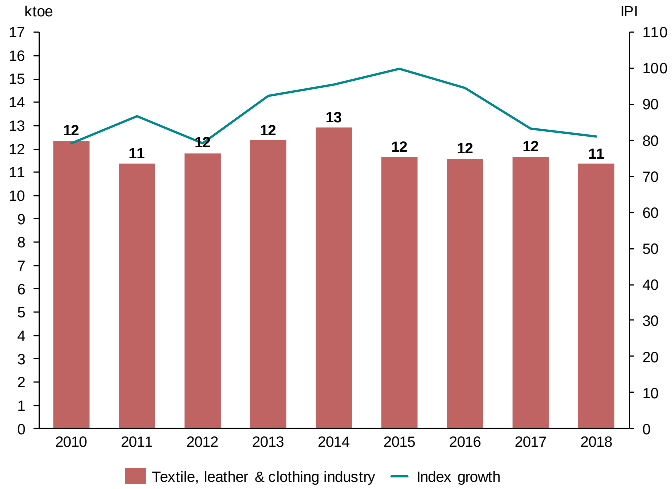


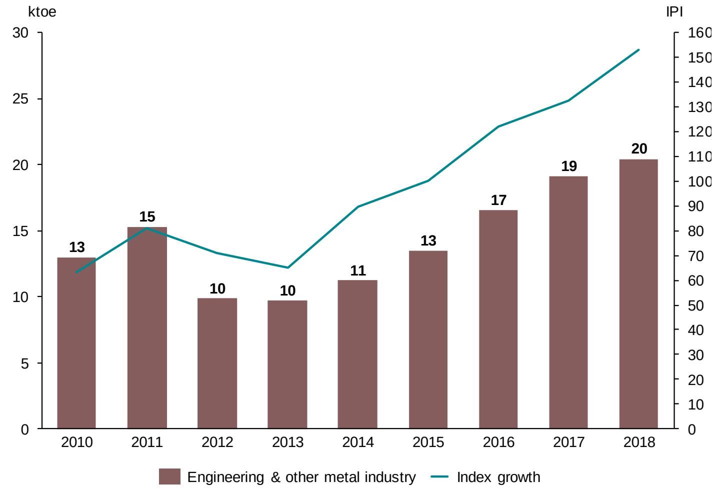
Although energy intensity shows how much energy is needed to produce a unit of product, it can also be used to monitor energy efficiency in each of the industry types. A significant improvement in terms of energy intensity of the Iron and steel industry can be noticed, especially after 2014 when the process of decoupling of energy consumption and the industrial production index can be seen from Figure 8 and Figure 9. Significant improvements have also been made in the Glass, pottery and building mat. industry, Food, drink and tobacco industry and the Engineering and other metal industry. One of the goals of this study is the trend of energy efficiency improvements to continue, which will increase the industrial production index, while decreasing energy consumption.

Figure 9. Energy consumption and industrial production index by industry branches









GHG EMISSIONS FROM THE INDUSTRY

As stated in the introduction, GHG emissions that are directly related to the Industry, according to the IPCC methodology, are reported in three sectors: Energy (Manufacturing and Construction Industry), IPPU and Waste (Industrial Waste and Wastewater Treatment and Discharge of the Industry). It can be noted that in 2016:

- the total GHG emissions from the Industry in the Energy sector are 1,037 ktCO_2-eq, which represents about 14% of the total emissions from the Energy sector (Figure 10, Figure 11). Following the energy consumption by industrial types, the GHG emissions are the highest in the Iron and steel industry and the Glass, pottery and building mat. industry with a share of 52% and 28% in 2016, respectively.
- the total GHG emissions from Industry in the IPPU amounted to 540 kt CO2-eq (Metal and Mineral industry), which represent 63% of total emissions in the IPPU sector (Figure 12)
- the total GHG emissions from the Industry in the Waste sector amount to 103 ktCO_2-eq, representing 16.9% of the total emissions in the Waste sector (Figure 13).

Figure 10. GHG emissions from the Energy sector (kt CO_2-eq)

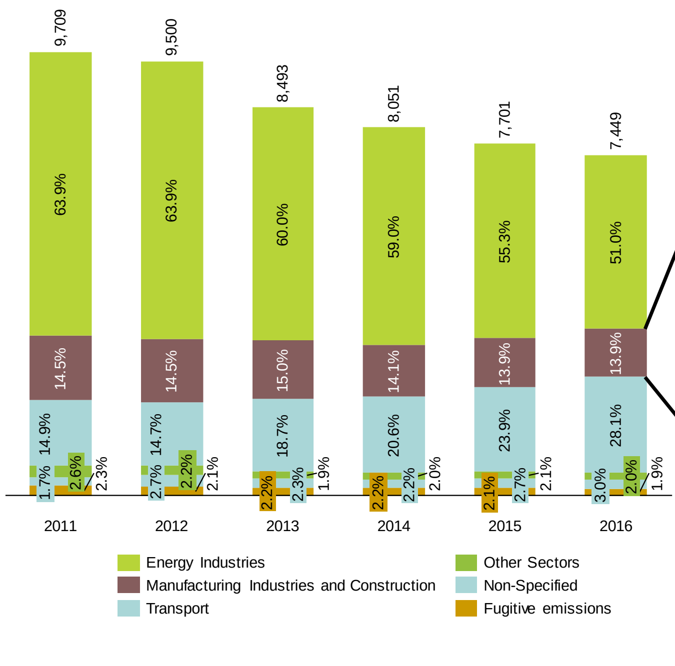


Figure 11. GHG emissions by industry branches (kt CO_2-eq)

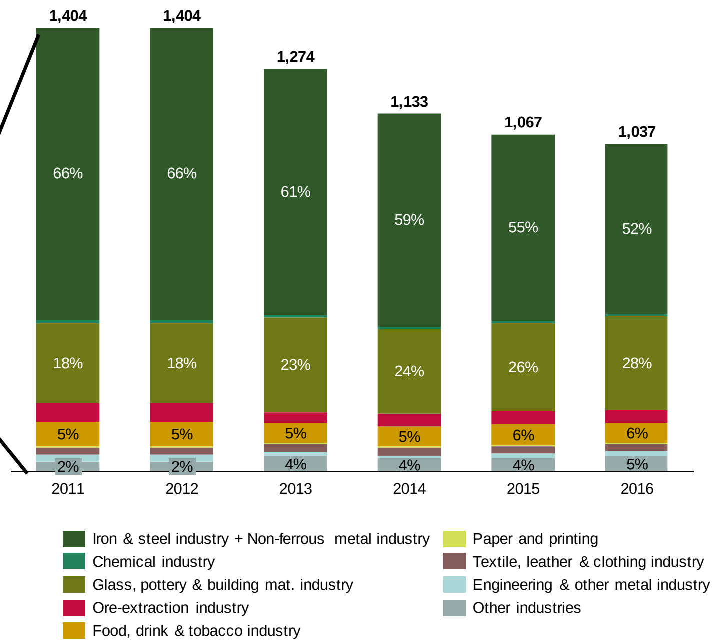


Figure 12. GHG emissions from the IPPU sector (kt CO_2-eq)

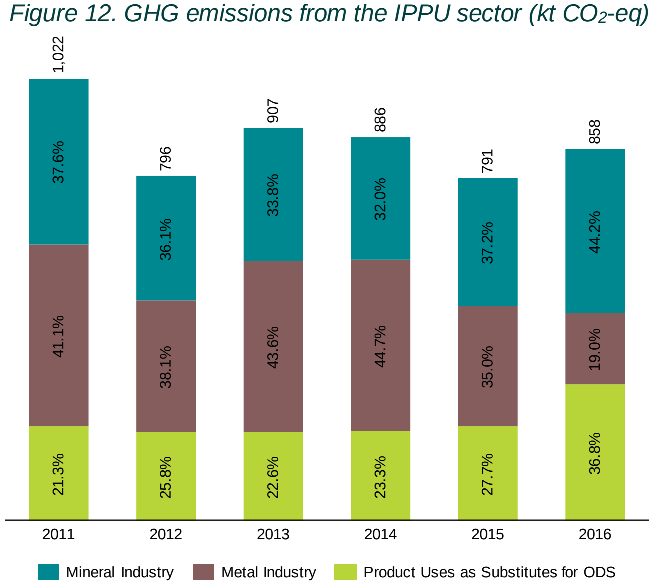
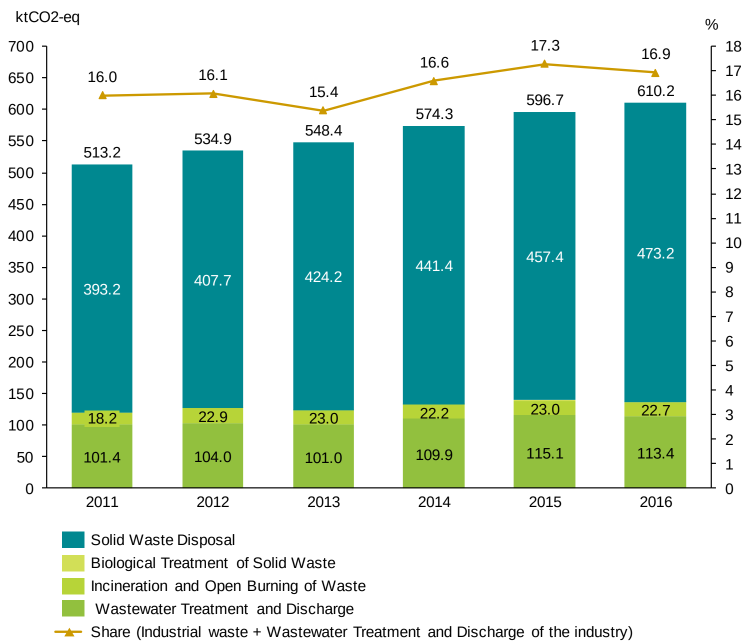


Figure 13. GHG emissions from the Waste sector



On the other hand, the IPPU sector participates with about 8% in the total GHG emissions, the Energy sector participates with about 75%, and the Waste sector with about 6% (Figure 14). If the GHG emissions from the Industry in all three sectors are added, it is obtained that its share is about **16.7%** in the total GHG emissions in 2016 (Figure 15).

Figure 14. GHG emissions by sectors (kt CO_2-eq)

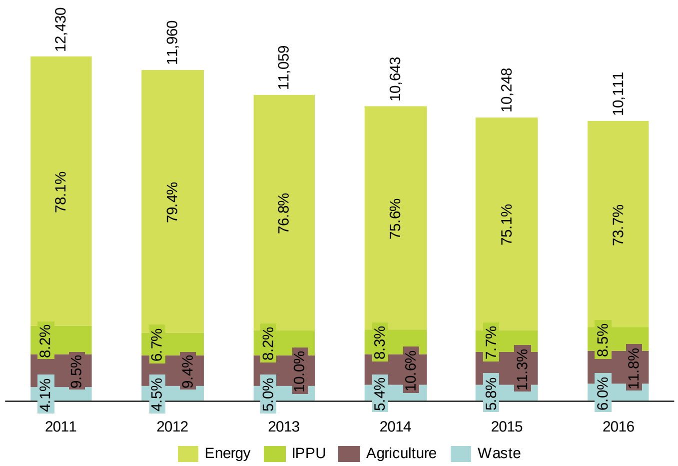
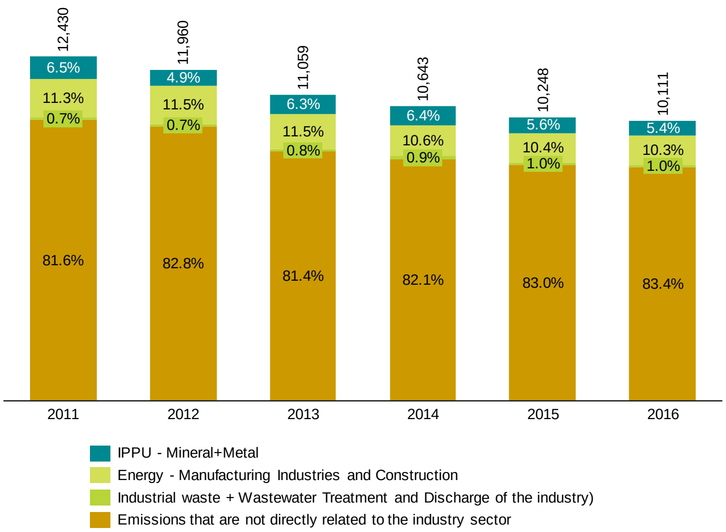


Figure 15. Share of Industry in total GHG emissions (%)



POWERFULL INDUSTRY

„In the new world, it is not the big fish which eats the small fish, it's the fast fish which eats the slow fish"

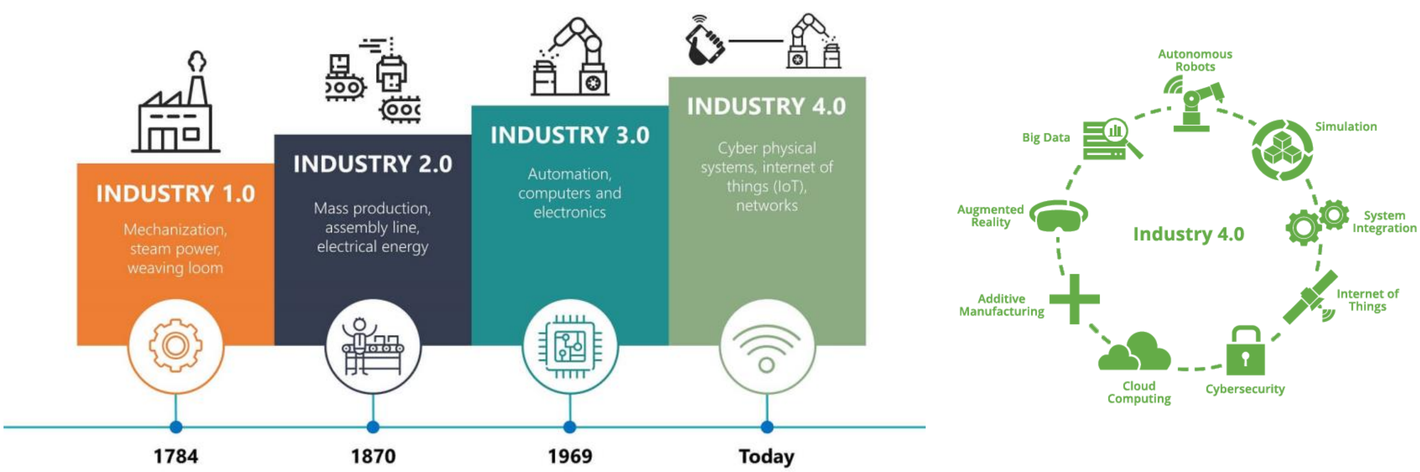
Klaus Schawab

To enable sustainable development, the Industry also needs to contribute to this process. On the other hand, for the Industry to be able to contribute to sustainable development, companies need to be familiar with this concept. It often happens that company managers do not pay enough attention to the optimal use of energy and resources. In fact, in addition to the economic aspect, companies need to take into account the environmental effect and the social aspect in order to be sustainable.

Over the years, the Industry has developed significantly, and this process can be summarized in four main periods (Figure 16). Starting with the introduction of the first machines that worked with steam and water in the Industry 1.0 phase, through the introduction of electricity, engines and assembly lines for mass production in the Industry 2.0 phase and the introduction of automation, computers and electronics in the Industry 3.0 phase, today Industry 4.0 is being developed. At this current stage, the Industry uses intelligent automated devices, networking, i.e. connecting all elements involved in the production, their independent optimization and production control. The transition to this stage provides efficiency, flexibility and many opportunities for further development of the Industry, and thus greater competitiveness, improvements in working conditions and compatibility with the environment.

According to the study "Current status of research, development, innovation and technology transfer related to climate change in the Republic of North Macedonia"[3], the world's largest investments are in information technology, biotechnology and climate technology. But when it comes to Industry 4.0, you can't tell the difference between information technology and climate technology because Industry 4.0 is largely driven by information technology, which is also climate technology because it mitigates the Industry's negative impact on climate change.

Figure 16. Industry development



[3] https://klimatskipromeni.mk/article/415#/index/main

In addition to technological improvements, companies need to adapt to new economic trends. Namely, the concept that the companies have applied so far has been based on a linear economy (Figure 17), which in turn is not in line with sustainable development. The main disadvantage of this concept is that the resources are extracted, reducing their quantity, are used and disposed without being re-used, which in turn increases the amount of waste. The Industry sector is the main driver that should enable this concept to be replaced by the concept of a circular economy (Figure 18). The circular economy involves the reuse of resources and world-renowned companies, such as IKEA, Caterpillar, Tarket, etc. are the leaders of this concept. On the other hand, the circular economy should be developed in parallel with the "greening" of the Industry (Table 3). This primarily involves the introduction of energy efficiency and the use of renewable energy sources.

Figure 17. Linear economy

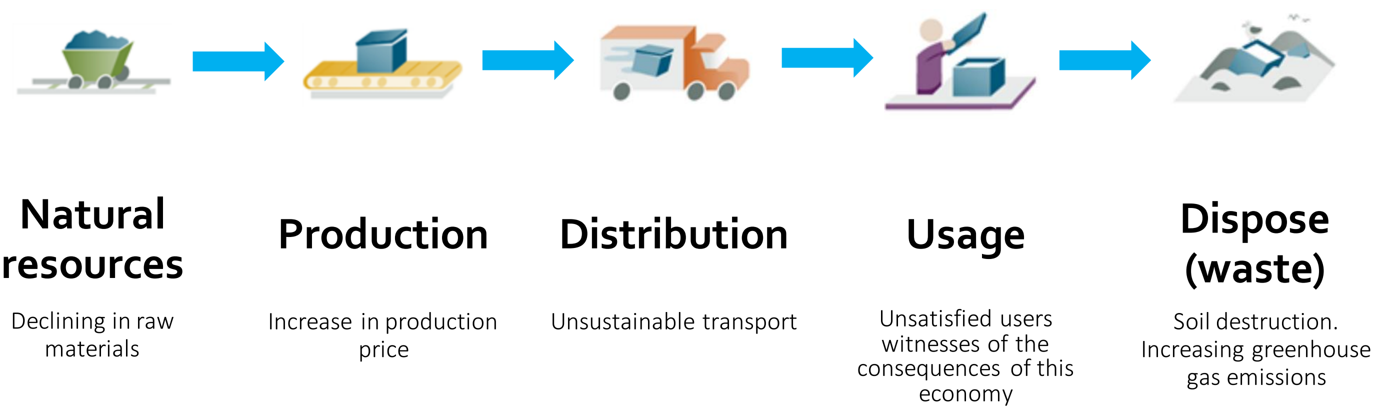


Figure 18. Circular economy

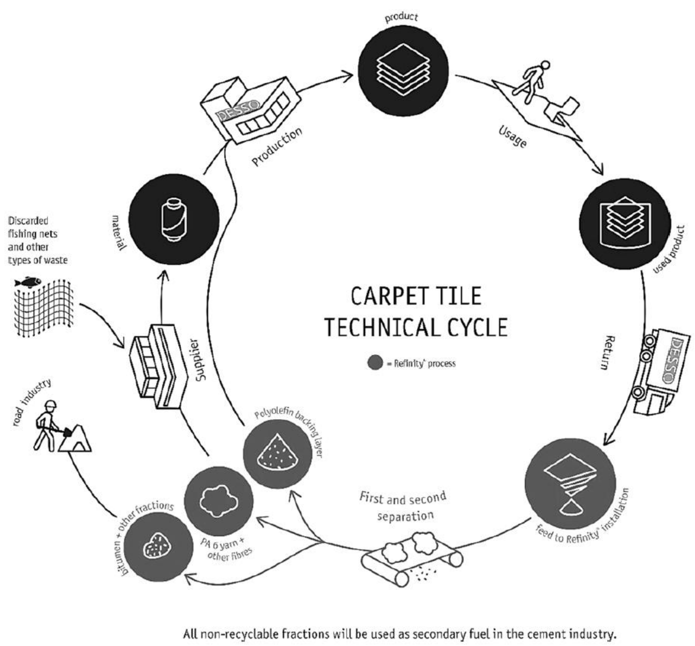


Table 3. "Greening" the industry

"Greening" the industry Companies to improve productivity and care for the environment	***Creating a green industry***
▪ Efficient use of materials, energy and water ▪ Reduction of waste and emissions of pollutants ▪ Safe and responsible chemical management, renewable raw materials ▪ Non-use of toxic substances ▪ Replacement of fossil fuels with renewable energy sources ▪ Using recycled raw materials ▪ Product and process redesign	▪ Reduction, reuse and recycling (3R industries) ▪ Technology and equipment for pollution control ▪ Renewable and energy efficient technologies Промена на процесите на производство и редизајн на производи ▪ Processes of production changes and redesign of products ▪ Waste management and resource recovery

SCENARIO WITHOUT MEASURES (WOM)

„Climate change is no longer some far-off problem it is happening here it is happening now"

Barack Obama

The scenario without measures, which is used to calculate the contribution of each measure to GHG emissions, as well as local emissions reduction, is the same as the scenario without measures from TBUR and the Energy Strategy until 2040, the part for energy efficiency. A detailed overview of this scenario is given in these documents, and in this study, only the Industry part is highlighted.

In this scenario, the final energy consumption in the Industry increases by 184% in 2040 compared to 2017 (the year which is used as a base year for the modeling), and coal and electricity will continue to be the main energy sources (Слика 17). Besides, the Iron and Steel Industry will remain the largest participant in the final energy consumption, reaching 56% by 2040 (Слика 18).

Figure 19. Final energy consumption in the Industry by fuels (во ktoe)

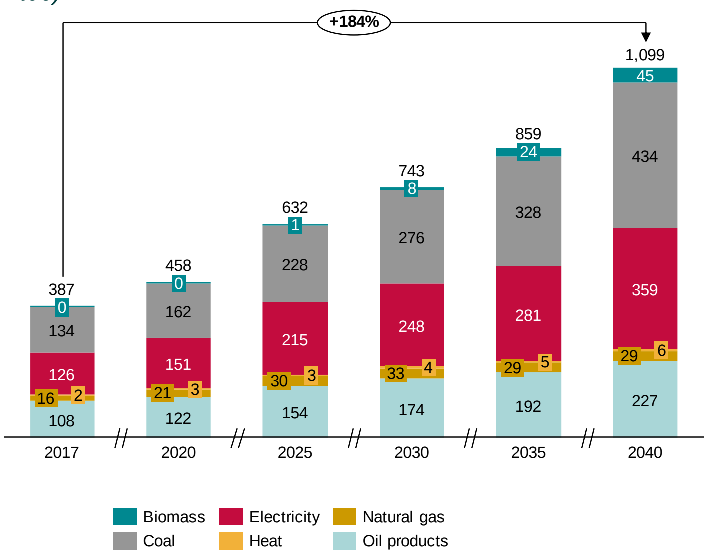
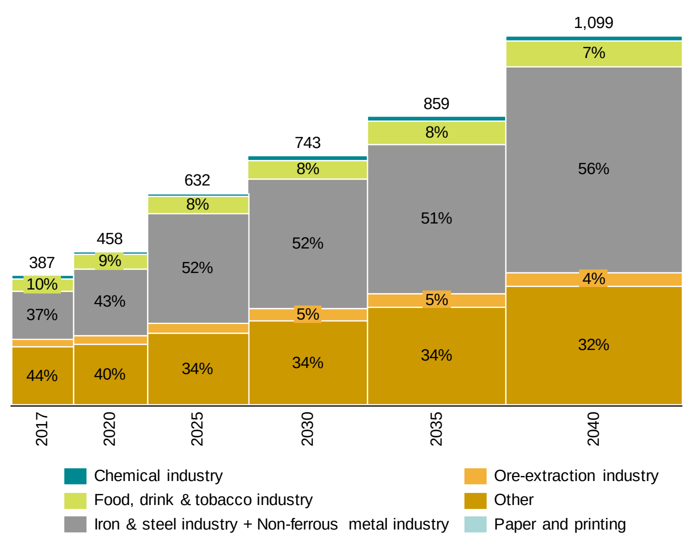


Figure 20. Final energy consumption in the Industry branches (во ktoe)



In this scenario it is projected that:

- The emissions from the Energy sector will increase by 1.7 times in 2040 compared to 2017, while emissions from Industry (Manufacturing and Construction Industry) in the Energy sector will increase at a higher rate and will be 2.8 times higher in 2040 compared to 2017, mostly as a result of the increased consumption of coal in the Industry (Figure 21),
- Emissions from the IPPU sector will be almost doubled in 2040 compared to 2017, while emissions from Industry (Metal + Mineral) in the IPPU sector will increase by 1.4 times in the same period (Figure 22),
- Emissions from the Waste sector will increase by nearly 1.5 times in 2040 compared to 2017, while emissions from Industry (Industrial Waste and Wastewater Treatment and Discharge of the industry) will be more than doubled in the same period (Figure 23).

Figure 21. GHG emissions from the Energy sector (kt CO_2-eq)

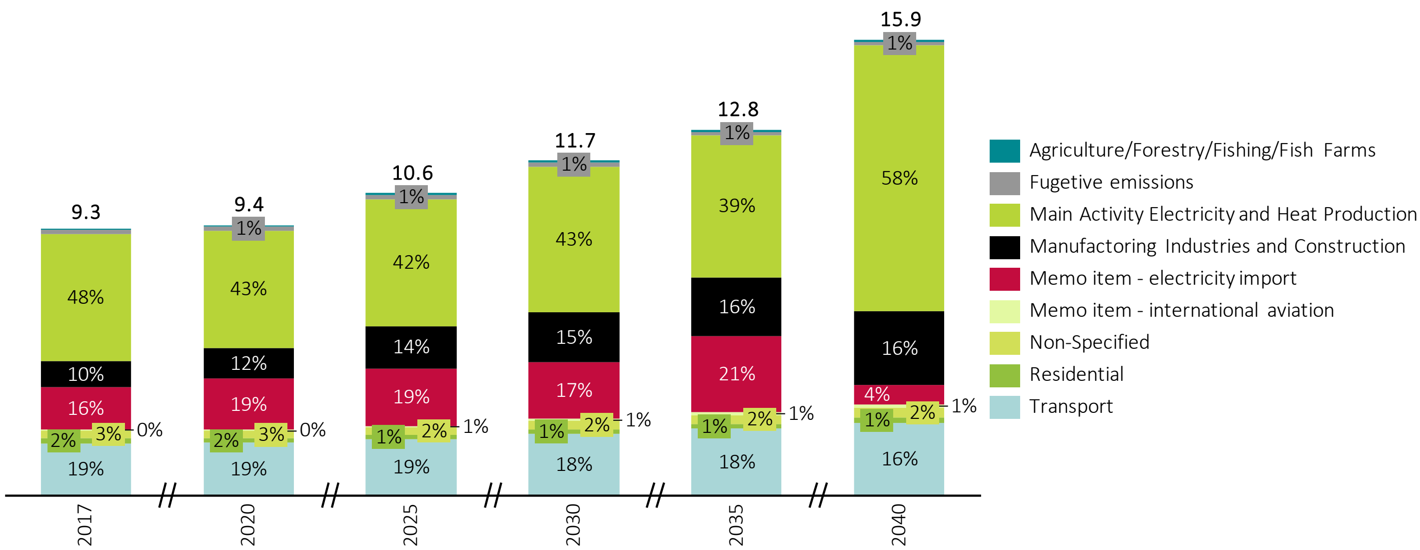


Figure 22. GHG emissions from the IPPU sector (kt CO_2-eq)

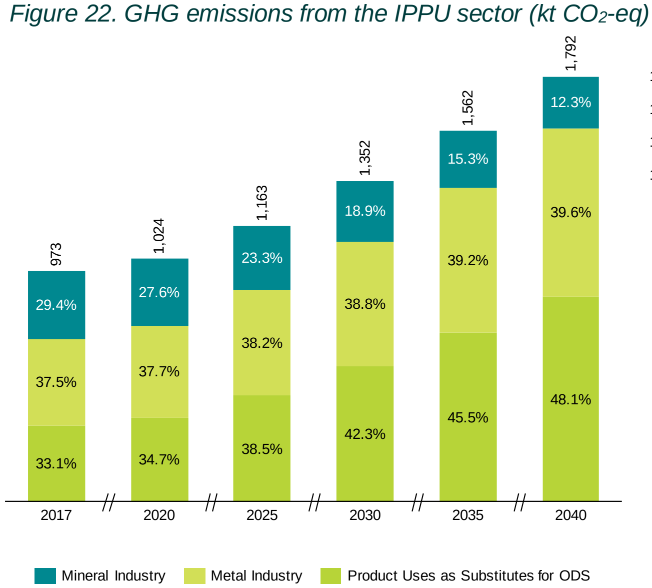
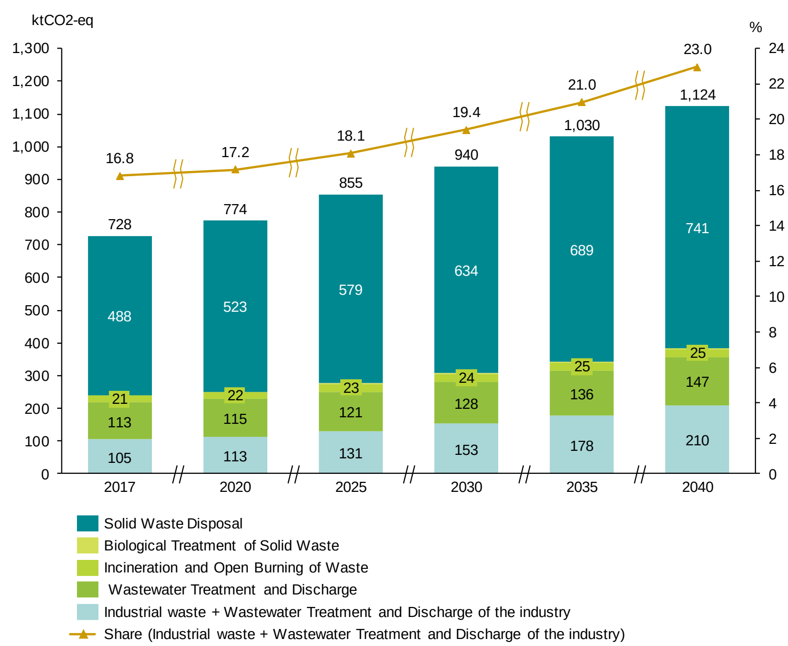


Figure 23. GHG emissions from the Waste sector



On the other hand, the total emissions in this scenario will increase by about 75% in 2040 compared to 2017, with a dominant share of the Energy sector (Figure 24). The share of Industry in total emissions will be increased from around 15% in 2017 to above 19% in 2040 (Figure 25).

Figure 24. GHG emissions by sectors (kt CO_2-eq)

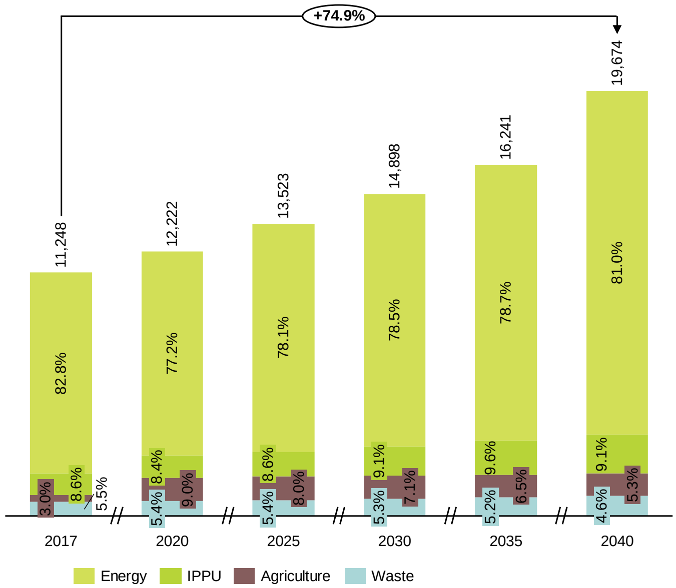
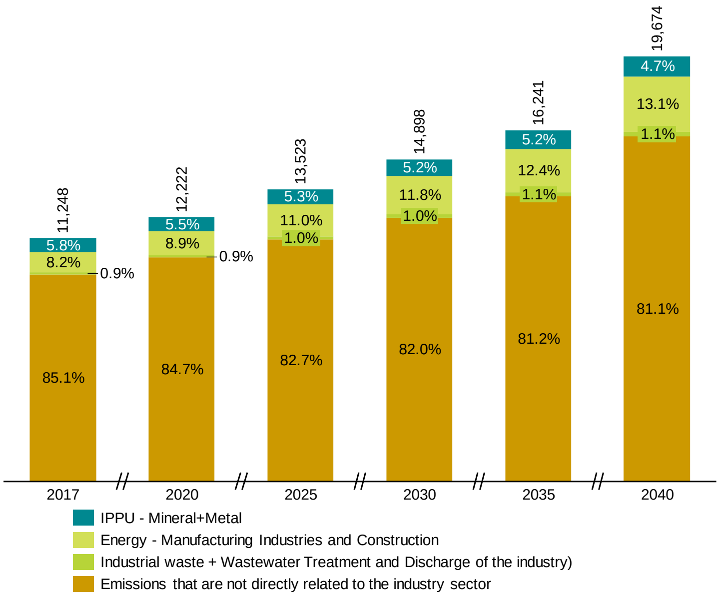
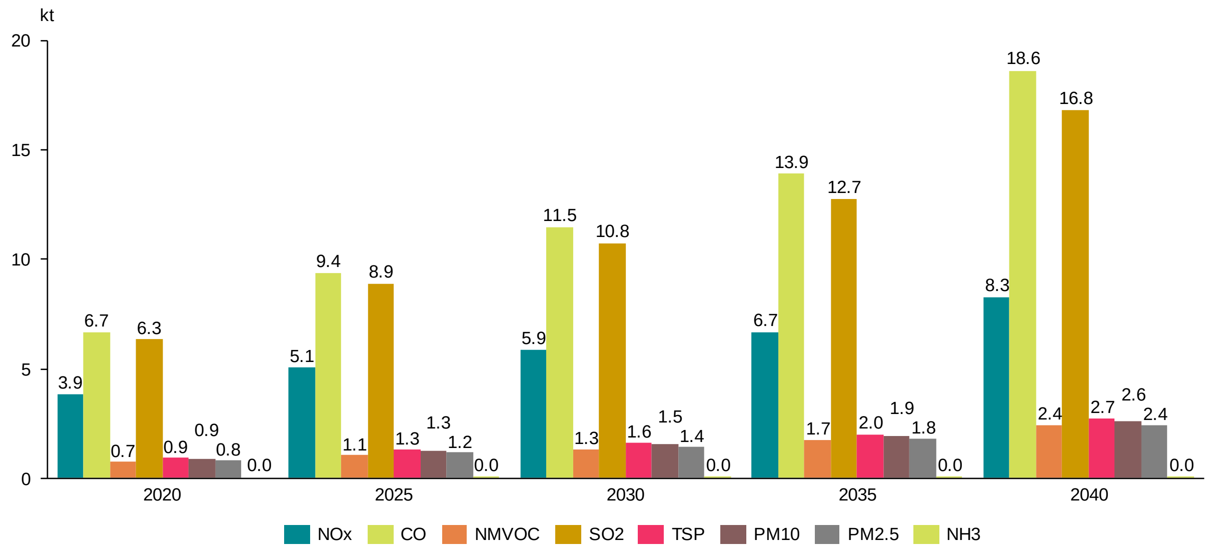


Figure 25. Share of the Industry in the total GHG emissions (%)



According to the increase in GHG emissions, local emissions from each type of pollutant will also increase. From the Industry in the Energy sector, local emissions will increase by about 2.7 times in 2040 compared to 2020 (Figure 26). The amount of local emissions is calculated according to the Tier 1 methodology that depends on energy consumption. However, how much of this amount will be released into the air depends on the built-in technology following the environmental standards that Industry entities need to meet.

Figure 26. Local emissions



POSSIBILITIES IN THE INDUSTRY

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."

Albert Einstein

There are numerous possibilities in the Industry for reducing energy consumption, and thus for reducing costs and emissions. As part of this study, several measures and policies have been summarized and distributed in eight groups, seven of which are in the Energy sector and one in the Waste sector. In addition, some of these groups are branched out into multiple policies and measures, with the aim of modeling and examining their individual effects in more details:

1. Energy management
2. Sort measures
3. Energy performance of buildings
    a. Lighting
    b. Heating, ventilation and air conditioning - HVAC
    c. Insulation, windows and doors
4. Motors
    a. Proper maintenance and use of existing motors
    b. Motors replacement
    c. Air compressors replacement
    d. Pumps replacement
5. Introduction of CO_2 tax
6. Change in the process design
    a. Process change
    b. Steam systems
    c. Cooling
7. Solar rooftop
8. Improved waste and materials management

1. ENERGY MANAGEMENT

Description: Energy management systems can be defined as a set of interconnected tools for monitoring, controlling and optimizing energy consumption. In doing so, the system includes establishing an energy policy within a company, setting energy goals, and the technologies and procedures needed to achieve the set goals. There are a variety of cost-effective technologies on the market that are capable of improving the energy efficiency and thereby reduce emissions and costs in various industries. The identification of the need and application of such technologies is realized with the help of Energy management. Therefore, the introduction of an Energy management system is recommended as a first step, as a precondition for the implementation of other appropriate measures and policies.

In Energy management, a structured process should be followed, based on a model of energy maturity, according to which measures can be divided into several steps, from those that require small or no investment, to the measures in which investment costs are significant:

- **Housekeeping.** These are measures to which priority should be given because usually, they are “no-cost” measures or small investments are needed and are called soft measures. Individual benefits in reducing the energy consumption of each of these measures can be small, and therefore often these measures can be ignored. But if their contribution is integrated, it can be significant.
- **Use of control systems.** The introduction of control systems can enable the processes to operate closer to their designed control limits, which can optimize energy consumption. These systems usually do not have a large investment. Examples falling within this category are: control of the temperature of the air conditioning system, use preventive maintenance and monitor the situation to predict and to prevent defects of the equipment, reduce the excess flow, monitor the performance and power consumption of key units in the system, use of variable speed drives, etc.
- **Need for system thinking.** In the Industry sector, most of the systems are made up of components that are interconnected by pipes or cables. Measures in this area may include simple modifications, but also an integration of energy consumption throughout the system. Examples falling within this category are: use of compact heat exchangers, use of boilers for utilizing the waste heat, use of pre-heaters, heat from one process re-used in another process, intensification of processes, analysis of thermal excesses, removal of bottlenecks, overall optimization of the whole process to minimize total energy consumption.
- **Change in process design and/or energy supply.** The biggest opportunities for energy savings, but also the biggest investment risk is in modifying the design process and the change of energy supply. Examples in this category are: replacement of the production line with new process technology, utilization of energy or waste heat in a central heating and/or cooling network, change of the type of fuel used in the plant and the corresponding components.

Although different types of energy management systems exist and are implemented by companies, most of them are replaced by the introduction of the **ISO 50001 standard** in 2011 (currently, the latest edition is from 2018). This standard defines system requirements for energy management for an organization that helps enable continuous improvement of energy performance, including energy efficiency, use and consumption of energy. The standard provides a framework by which organizations should:

- develop policies for more efficient use of energy,
- set goals for fulfilling the set policies,
- use data to better understand and make decisions about energy use,
- measure the results,
- monitor how well the policies are implemented and continuously improve Energy management

ISO 50001 is a very important step in Energy management and should play a central role in the policies for improving companies' energy performance.

The process of implementing and maintaining an Energy management system, according to the ISO 50001 standard, includes the development of the system itself, internal and external control and certification. In doing so, involvement of experts, internal and external, is needed. In fact, one of the most important internal resources is the appointment of an energy manager (and possibly an energy management team) to develop and maintain an Energy management system. External resources include employee training, consulting services, external control and certification.

If a company does not decide to introduce the ISO 50001 standard, then for successful Energy management it is necessary to appoint an **energy manager** who will perform energy audit in the company, that will constantly monitor energy consumption and will propose appropriate measures to optimize it. The energy manager may already be an employee of the company who knows the process well and may be assigned to this position, but in some cases, additional employment may be required. The company can also hire an external energy manager.

Legal support in Macedonia: According to the Law on Energy Efficiency, all large enterprises are obliged to perform energy audit every four years, by external or internal (company employees) authorized energy auditors. According to the Law, energy audit provide:

- assessment of the possibilities for reducing the energy consumption in the buildings, the accompanying (auxiliary) facilities, equipment and industrial processes;
- determination of the achieved savings as a result of the applied the measures for improving the energy efficiency and energy saving; and
- reducing emissions of harmful substances into the environment.

The ISO 50001 standard is not mandatory for companies, but if a large company owns it then it has no obligation to conduct an energy audit. Also, the company has no obligation to conduct regular energy audit if the energy audit is implemented as part of an environmental management system under an integrated environmental permit issued in accordance with the regulations in the field of environmental protection, if the energy audit meets closer requirements prescribed in the Rulebook on Energy Audit of the Large Enterprises.

According to the Law, Large enterprises are entities established in accordance with the Law on Trade Companies that, in each of the last two accounting years, or during the first year of activity, have met at least two of the possible three criteria, as follows:

a) the average number of employees, based on working hours, exceeds 250 employees,
b) the annual income exceeds EUR 10,000,000 equivalent in denar countervalue, or

c) the average value (at the beginning and at the end of the accounting year) of the total
d) assets of the company exceeds EUR 11,000,000 equivalent in denar countervalue;

Type of industry: For all types of industries

Investment: 100.000-250.000 EUR

Case study in Macedonia: With the support of the UNIDO project in Macedonia, 23 companies have successfully implemented the process of implementation and certification of the ISO 50001 standard. The introduction of this standard has allowed companies to identify and implement measures to reduce energy consumption, with a payback period of less than three years. Using this standard, in the period 2016-2017, the companies had significant improvements in energy performance, such as:

- Vardar-Dolomit – 7.9%
- Makstil – 7.5%
- Alkaloid – 6.24%

With the help of the "Industrial Management Project" (USAID), in seventeen industrial companies throughout Macedonia modern systems for energy management are installed, so that the companies can regulate their energy use.

In addition, the Ministry of Economy prepares an annual Program for Competitiveness, Innovation and Entrepreneurship, which, among other things, provides support to companies for the implementation of measures in the field of industrial policy. One of these measures in 2019 is the reimbursement of part of the costs for the preparation of projects for energy efficiency and/or the introduction of the standard for energy management ISO 50001. The cost reimbursement is in the amount of 75% of the proven costs, but not more than 300,000.00 denars (~5,000 EUR) individually for each company. In 2019, the company LARS DOOEL - Stip received support for the implementation of this measure in the amount of 236,250 denars (~3,800 EUR).

2. SOFT MEASURES

Description: This group includes measures used for "housekeeping" operations (according to the classification made in the Energy management measure). In fact, after the implementation of the Energy management measure, the first measures to be implemented are the “no-cost” measures or the measure for which small investments are needed. These include:

- turning off things when they are not needed or not used (such as lights, machines, etc.),
- good maintenance,
- improving insulation and
- reduction of: leakage (e.g. water, air, oil, fuel, heat, steam, etc.), waste, idle time and losses.

In the implementation of these measures, it is important that all employees in the company actively participate, so that they will be encouraged not only to follow the recommendations, but also to be involved in identifying opportunities for housekeeping. The active involvement of employees can be assisted by their participation in various trainings in this area.

Type of industry: For all types of industries

Investment: Negligible

Case study in Macedonia: With the help of the UNIDO project in Macedonia, the first measures implemented in companies are soft measures, such as:

- Repair of air leakage in the flue gas channel in REK Bitola;
- Turning off lights from other floors that are not used during the night in Vardar-Dolomit;
- Automatic door closing systems in Comfy Angel.

Additionally, in a conversation with the people involved in the implementation of ISO 50001 in the UNIDO project in Macedonia, it was pointed out that often the potential for soft measures is much greater than the initial calculations. This is due to the establishment of measurement systems, which raise the awareness of employees and managers about the importance and opportunities for optimal energy use. In one such example, power consumption was reduced by up to 30%, as a result of switching off one machine in the hours when there was no production process from it.

Also, through the Competitiveness, Innovation and Entrepreneurship Program of the Ministry of Economy in 2019, two specialized trainings were co-financed - Training for introduction of the concept of "greening" in the manufacturing industry and Training for introduction of the concept of circular economy in manufacturing. Both trainings have been successfully completed.

3. ENERGY PERFORMANCE OF BUILDINGS

Description: Usually, industrial facilities aim to increase energy efficiency by improving the process that uses most of the energy and whose investment cost is far greater than the cost of the building in which the company is located. However, measures for improving the energy performance of buildings should also be taken into consideration because they can bring the companies closer to their set goals for energy savings in a simplified way, and also improve the comfort and health of employees. At the same time, these measures can serve to raise awareness among employees in the company of the importance of optimizing energy consumption. In this group of measures, it is planned to improve the performance of buildings, mainly by improving:

- **Lighting –** Replacing old bulbs (for example, incandescent or halogen bulbs) with LED and the possibility of their automatic turning on/off using sensors;
- **Heating, ventilation and air conditioning (HVAC) –** Introduction of heating, cooling and ventilation systems with greater efficiency, as well as the possibility of their automatic regulation;
- **Insulation, windows and doors –** Replacing old windows and doors with new ones and installing or adding insulation to the building itself.

Type of industry: For all types of industries

Investment: For lighting, heating, cooling and ventilation, investments are usually low, while for insulation, the investment depends on the size and type of the facility but is usually big.

Case study in Macedonia: After the implementation of soft measures, the measures for lighting is most often realized, but also the measures for heating, cooling and ventilation, followed by the measures for insulation, windows and doors. For example:

- Vardar-Dolomite made replacement of part of the bulbs with LED lights, installed automatic control of the heating system and enabled heating of one of the rooms from process heat;
- Comfy Angel replaced the lights with more efficient ones, introduced their automatic switching and introduced temperature control in all working areas;
- In Toranica, a part of the lights has been replaced with new LED lights;
- Alkaloid made replacement of old windows in the main building.

4. MOTORS

Description: Motors are components that are present in various industries and it is estimated that around the world motors make up about 60% of the electricity consumption in the industry. They can be found in pumps, fans, compressors and in various drives. As part of this measure, there are four ways in which the energy consumed by the motors can be saved:

- **Proper maintenance and use of existing motors -** Improper maintenance, installation and use of motors can lead to significant electricity losses. Proper maintenance of motors and their regular inspection is very important. This includes monitoring the condition of the belts and their tension, proper lubrication and installation, repairing loose parts, cleaning the fins if they have cooling, etc. Pump-motor alignment can also be a source of energy losses and premature failure, so that this measure also takes into account this problem.

- **Motor replacement -** When replacing existing motors with new ones, the most efficient motor in existence should be used, because the cost of operation of the motors is hundreds and even thousands of times greater than the investment cost. According to the International Electrotechnical Commission (IEC), motors are classified according to the level of efficiency (as shown in Table 4). In addition to energy efficiency, when replacing motors with new ones, they must be the right size and, if appropriate, to be of the Variable Speed Drives type. This type of motor has the ability to convert the fixed frequency and voltage to variable values, which means that the motor speed can vary from zero to its maximum rated speed so that it can be adjusted to the actual energy demand at a given moment. It should be noted that this group of measures includes all types of motors, except motors in pumps and air compressors.

- **Air compressors replacement -** when replacing air compressors, in addition to what is stated in the part for motor replacement, special attention should be paid to the exact purpose of the compressor, i.e. knowledge of the environment in which it will work, in order for it to have appropriate airflow and a proper power outlet. In addition, the place where they will be placed should enable maintenance of the operating temperature, so that it can achieve the best performances.

- **Pumps replacement -** what is explained in the part for motor and air compressors replacement, also applies in the part of pumps replacement. In addition, for the pumps, the size of the pipes where they are supposed to be placed should be measured, because this is one of the parameters that affects their efficiency.

Table 4. IEC motor classification

TAG	LEVEL OF EFFICIENCY
IE2	Standard efficiency
IE3	High efficiency
IE4	Premium efficiency
IE5	Super premium efficiency

Type of industry: For all types of industries

Investment: Proper maintenance and use of existing motors has small investment, while motor replacement ranges from medium to high investment depending on the type of engine and its application.

Case study in Macedonia: Examples of measures that belong to this group, and are implemented by Macedonian companies are:

- Installation of a new efficient compressor with frequency regulation and installation of pump frequency regulation in Vardar-Dolomite;
- Examination of belts condition and tension in electric motors in Toranica;
- Installation of heat pumps in Comfy Angel

5. INTRODUCTION OF CO_2 TAX

Description: Introduction of CO_2 tax in order to stimulate fossil fuels use reduction or replacement of fossil fuels and higher penetration of the energy efficiency measures.

Type of industry: Energy intensive companies from all types of Industries.

Investment: No investment.

Assumptions: Introduction of CO_2 tax in 2023, using the forecasted prices in WEO 2017.

Legal support in Macedonia: The new Law on Climate action considers the possibility of introduction of CO_2 tax.

6. CHANGE IN THE PROCESS DESIGN

Description: The measures included in the group of change in the design process and energy supply have the highest opportunities for energy savings but are also followed by highest investments and thus risks.

- **Process change -** Introduction of more advanced technologies in industrial processes that will also allow the use of fuels that have less negative impact on the environment is envisaged under this measure. In addition to great opportunities to reduce energy consumption, this measure can help industries progress at a much faster rate. It is assumed that the introduction of CO_2 tax will mostly affect the change of the process, i.e. the fuels used in the processes. As a result, in this study, these two measures were implemented together.

- **Steam systems –** Significant part of the industrial processes use steam as an energy carrier. These include boiling, evaporating, drying, cleaning, sterilizing, certain chemical processes, and certain heat treatment. There are different ways in which the energy efficiency of these systems can be improved: reducing the number of heat transformations, use of air and water pre-heating, use of economizers, insulation of pipes, using efficient heat exchangers, minimizing the simultaneous heating and cooling, reuse of water and condensate.

- **Cooling –** systems for cooling (including refrigerators) are also common in the Industry. There are two types of cooling systems: air and water systems. These systems have the opposite role of the steam systems, i.e. their purpose is to take away the heat from the process. In addition to the considerations mentioned for motors and steam systems, the Coefficient of Performance (COP) of the cooling systems is also of great importance, which is a measure of their energy efficiency. It is also important for these systems to provide adequate access to cooling air in order to achieve their desired efficiency.

Type of industry: For all types of industries.

Investment: High

Case study in Macedonia: The following measures are introduced in the Macedonian companies:

- Installation of boiler economizer and fuel switch/new biomass/gas/diesel boilers in Comfy Angel;
- Steam management and boiler use optimization in Alkaloid.

7. SOLAR ROOFTOP

Description: This measure involves the construction of photovoltaic rooftop systems of industrial facilities, including the concept of producer-consumer. The main goal of this measure is to reduce GHG emissions, as well as to reduce air pollution from the Industry, but at the same time to increase the installed capacity of renewable energy sources in the country. It is estimated that the potential for the installation of photovoltaic power plants on the roofs of the industrial facilities is 120 MW by 2040.

Type of industry: For all types of industries.

Investment: 95 Mill. EUR

Case study in Macedonia: Through the Competitiveness, Innovation and Entrepreneurship Program of the Ministry of Economy in 2019, two companies were financially supported (IGMATOMI TEKS DOOEL and CVETKOSKI KOMPANI DOOEL) for Preparation of project documentation for installation of photovoltaic power plants for electricity production from renewable energy sources, with 288,374 denars (~4.700 EUR) and 101,518 denars (~1.650 EUR), respectively.

According to the Register for RES power plants it may be noted that certain industries have started with setting up photovoltaic plants on their roofs. The exact number cannot be determined because there are certain industrial facilities that have not yet been entered in this register.

8. IMPROVED WASTE AND MATERIALS MANAGEMENT

Description: This measure aims to reduce waste production, increase the level of selection, reuse, recycling and waste treatment in industrial facilities. Namely, each industrial capacity needs to submit proposals for 1) waste production, 2) waste selection, 3) waste reuse, 4) waste recycling, 5) waste treatment. Objectives are set in integrated environmental permits. The goals are set for a 5-year framework (progressive goals for each year) that will be updated accordingly after the deadline.

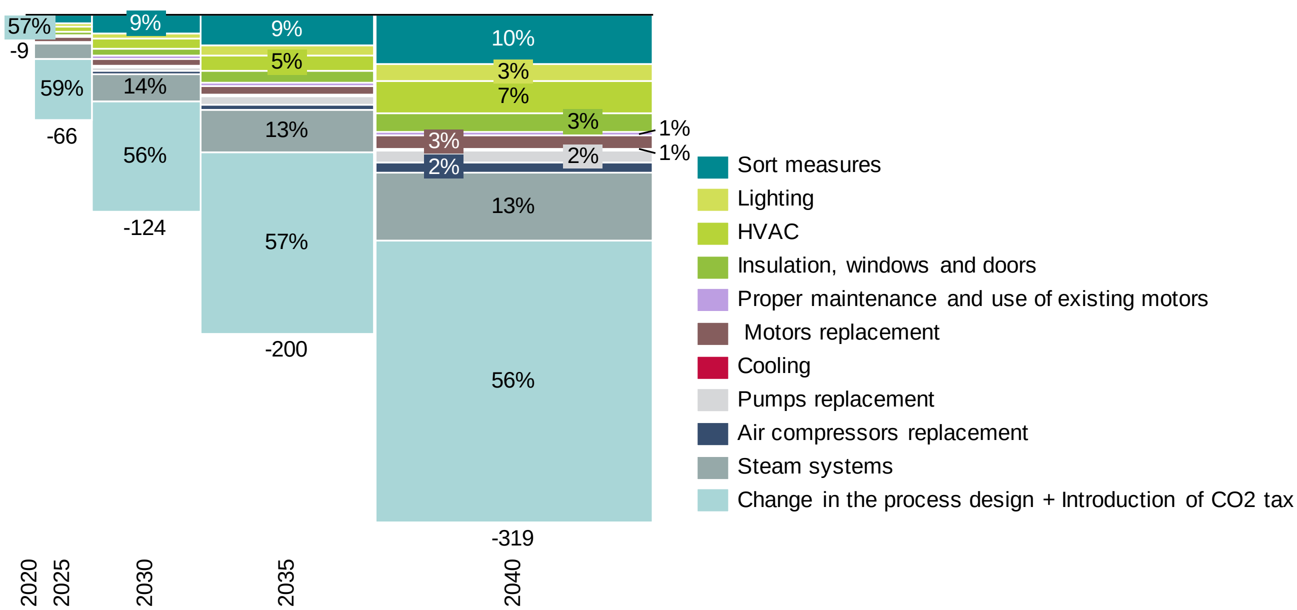
Type of industry: For all types of industries.

Investment: It cannot be determined.

RESULTS FOR THE INDIVIDUAL MEASURES

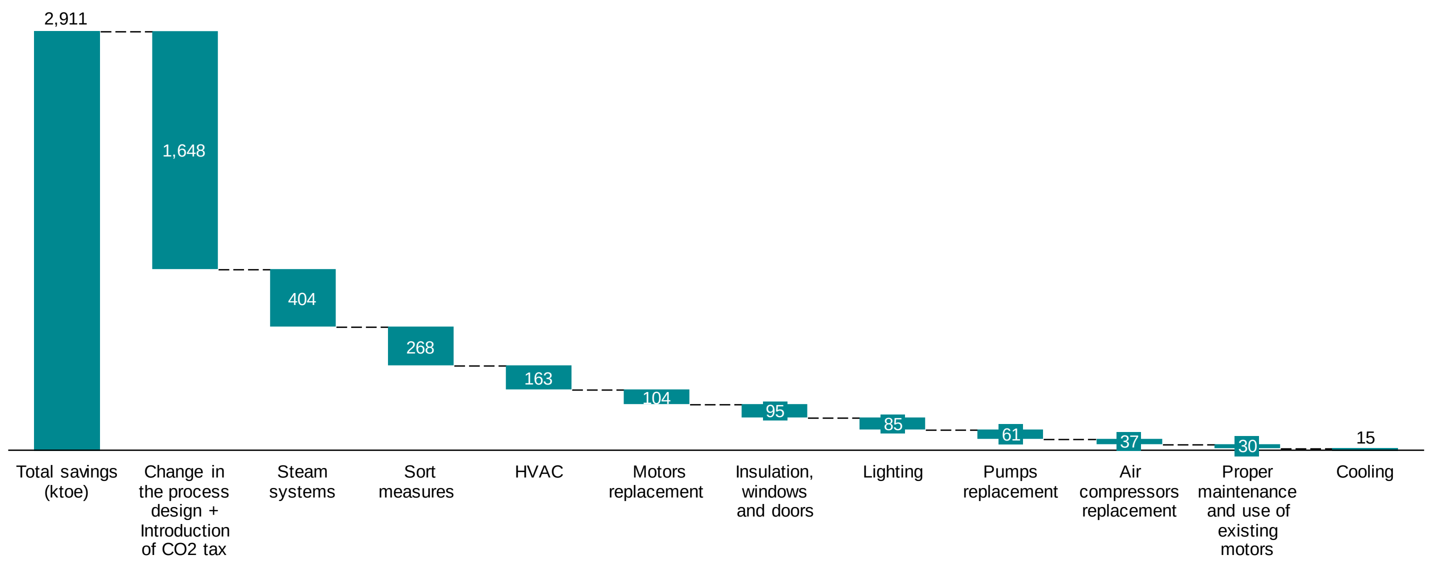
Each of the above proposed measures for GHG mitigation in the Industry from the Energy sector is modeled in the MARKAL-Macedonia model, while the IPCC software is used for the measure in the Waste sector. The contribution of each measure is calculated by comparing it with the WOM scenario. The results showed that, if the contribution of each measure was considered individually, the final energy consumption could be reduced by about 28% (320 ktoe) in 2040 (Figure 27) . This is in line with a number of studies that show that in the Industry sector in the period 2020-2040, 20-30% of final energy can be saved. More than half of the total energy savings during the entire planning period are result of the combination of process change and the introduction of a CO_2 tax (56% in 2040). With these two measures, by 2040, coal will be completely phased out as an energy source in the Industry and will be replaced mainly by natural gas and electricity. Measures with great potential for reducing final energy consumption are also Steam systems (13%), Soft measures (10%) and HVAC systems (7%). The cumulative savings in final energy consumption in the period 2020-2040 are 2,911 ktoe, which is 18% of the final energy consumption in that period (Figure 28).

Figure 27. Final energy consumption savings (ktoe)



Note: the Solar rooftop measure does not save final energy

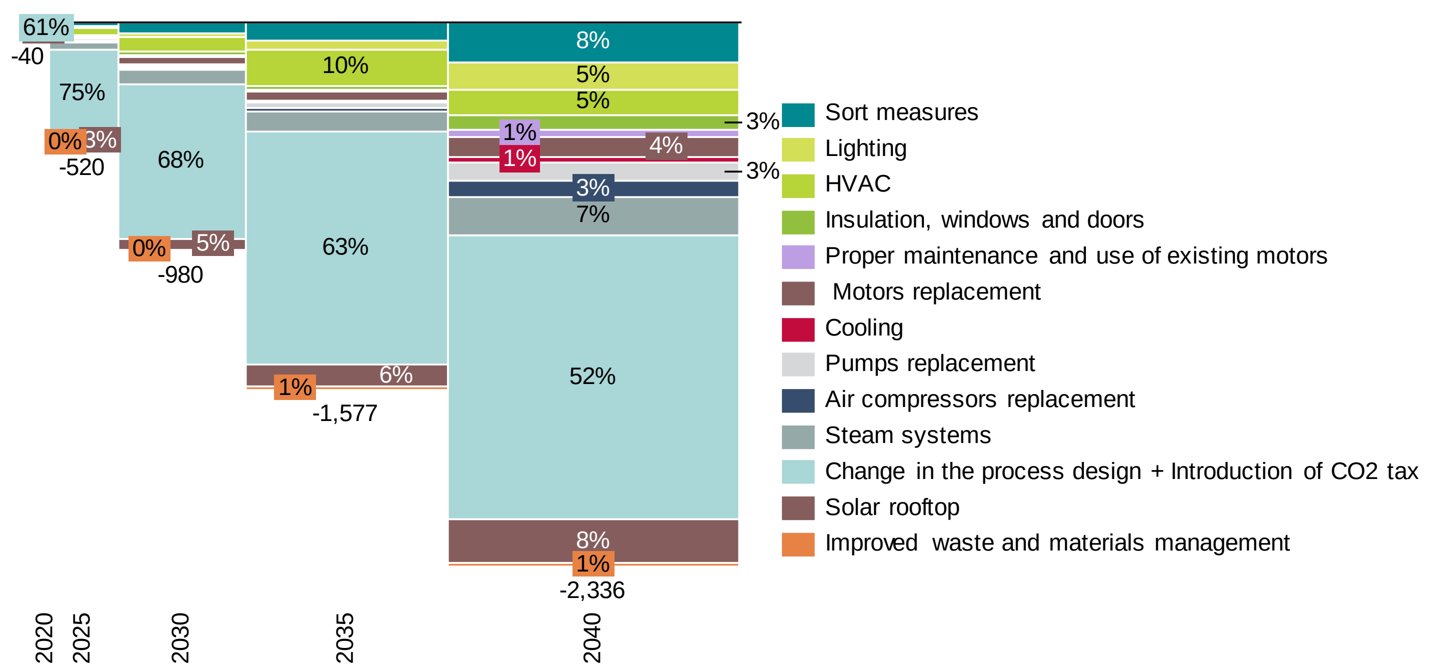
Figure 28. Cumulative savings on final energy consumption for the period 2020-2040 by measures (ktoe)



Note: the Solar rooftop measure does not save final energy

By implementing all the measures, it is obtained that the total GHG emissions from the Energy sector will decrease by about 15 % in 2040, compared to the WOM scenario. The highest contribution to this reduction again comes from the measure Process change (Figure 29).

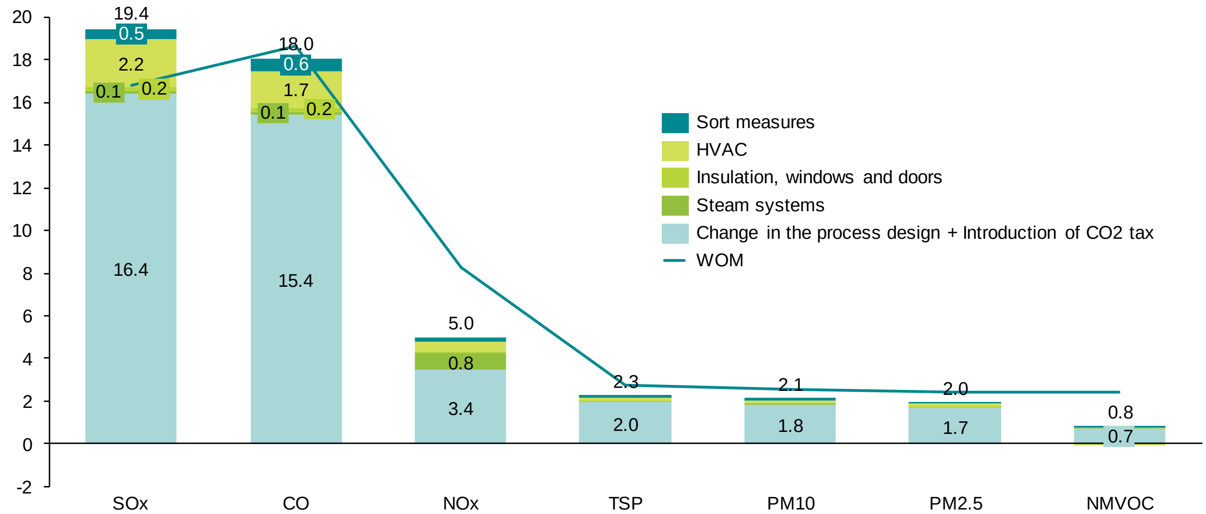
Figure 29. Reduction of the GHG emissions by measures (kt CO_2-eq)



The reduction in local emissions are only seen from the Industry in the Energy sector and therefore only five measures have the potential to reduce local emissions in this sector. By implementing the measures, SO_x and

SOₓ and CO emissions can be completely eliminated from this sector (Figure 30). As a result of overlapping certain measures, the sum of the potential to reduce SO_x emissions from individual measures is greater than the emissions in the WOM scenario.

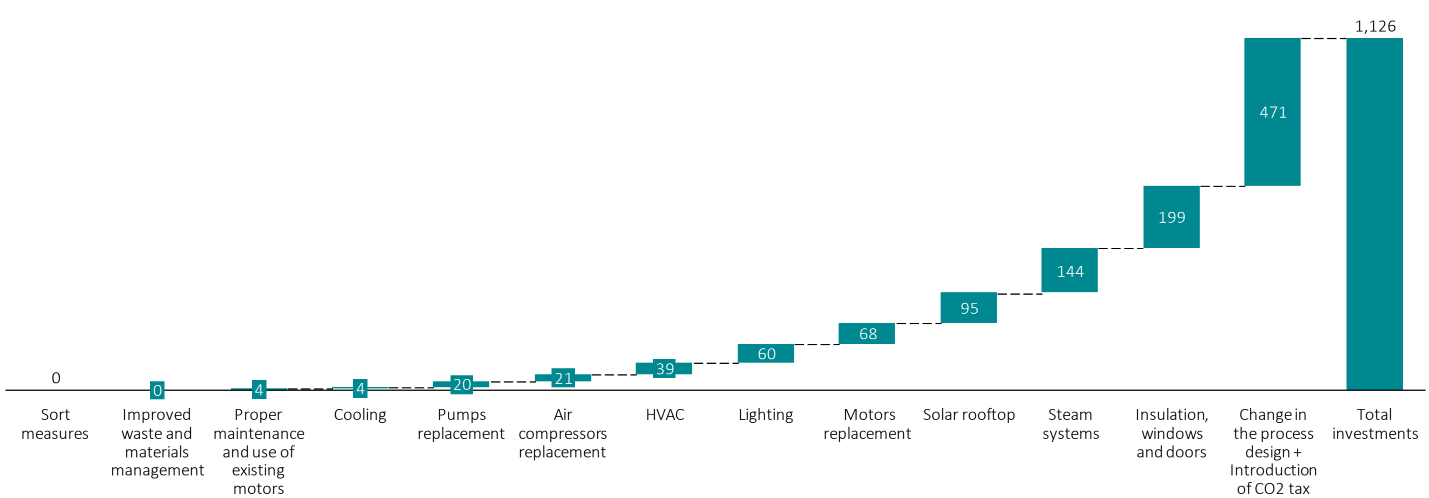
Figure 30. Reduction of local emissions by measures (kt)



INVESTMENTS

The total investment for the implementation of all measures is about 1,1 billion EUR, almost half of which is for the implementation of the measure Process change (Слика 25). The investments for the implementation of the measures proposed in this study are about 500 million EUR more, compared to the investments in the proposed measures in TBUR, because in this report additional measures are analyzed, such as Insulation (200 million EUR) and Steam systems (144 million EUR). On the other hand, the measures with the smallest investments are Proper maintenance and use of existing motors and Cooling, and for the Soft measures the investments are negligible. In addition, every large enterprise (under the Law on Energy Efficiency) needs to invest in the implementation of the 50001 standard or in the implementation of energy audit every five years.

Figure 31. Total investment by measures (mill. EUR)

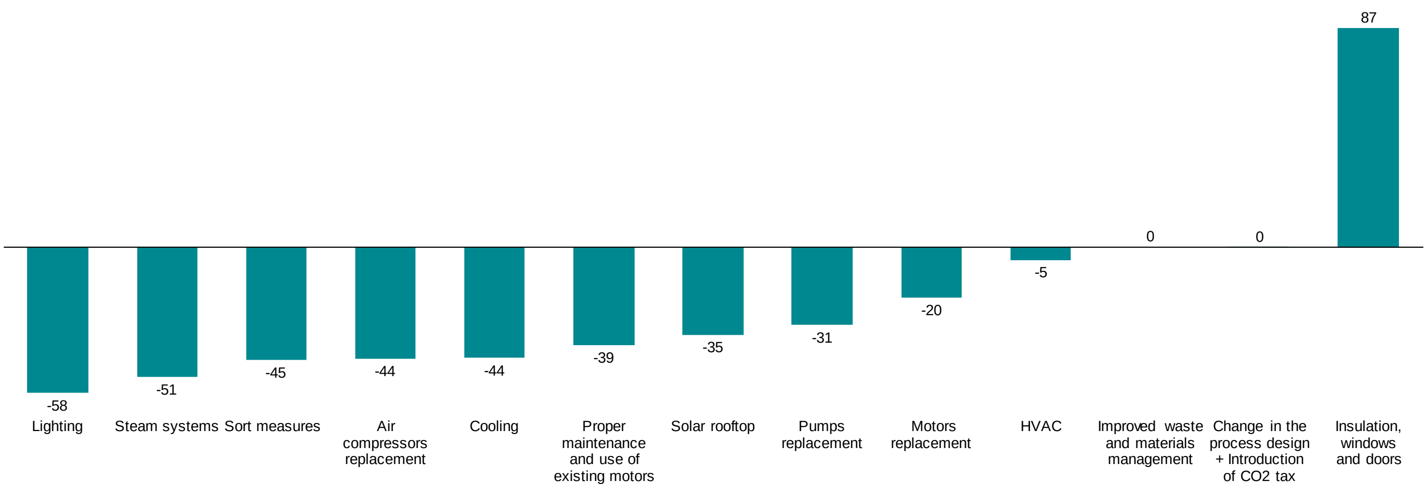


*If the difference in costs from the WOM scenario and the scenario with the implemented measure is divided with GHG reduced, the specific costs will be obtained for each measure, that shows their cost-effectiveness. The results show that except for the measure Insulation, all other measures have negative costs, which mean that these measures reduce GHG emissions at a price that is lower than the cost in WOM scenario (*If the difference in costs from the WOM scenario and the scenario with the implemented measure is divided with GHG reduced

Figure 32). The most advantageous measure for implementation is the measure Lighting, followed by the measures Steam systems and Soft measures.

If the difference in costs from the WOM scenario and the scenario with the implemented measure is divided with GHG reduced

Figure 32. Specific costs for 2030 (EUR/t)



SCENARIO FOR CLIMATE CHANGE MITIGATION

"The earth belongs to each of these generations, during it's course, so no generation can contract debts greater than may be paid during the course of it's own existence.

Thomas Jefferson (1798)

In order to take into account the interaction of the proposed measures, a scenario has been created in which all measures have been implemented together. In this scenario, the final energy consumption will be reduced by 262 ktoe (24%) in 2040 compared to the WOM scenario (Figure 33). The Process change measure, which means transition from coal (which includes oil and petroleum coke) to using natural gas and renewable energy sources (biomass), contributes to the most in the reduction of the final energy consumption. On the other hand, this process is followed by an increase in natural gas consumption by about 240 ktoe in 2040, compared to the WOM scenario. Given that coal is mostly consumed by the Iron and Steel industry and Other industries (glass and ceramics industry, textile and leather industry, engineering and other metal industry and other industries), these industries contribute the most to the reduction of the final energy consumption (Figure 34). At the same time, these two industries have the highest percentage of reduction in energy consumption (24.5%) compared to their consumption in the WOM scenario (Figure 35).

Figure 33. Final energy consumption savings by fuels (ktoe)

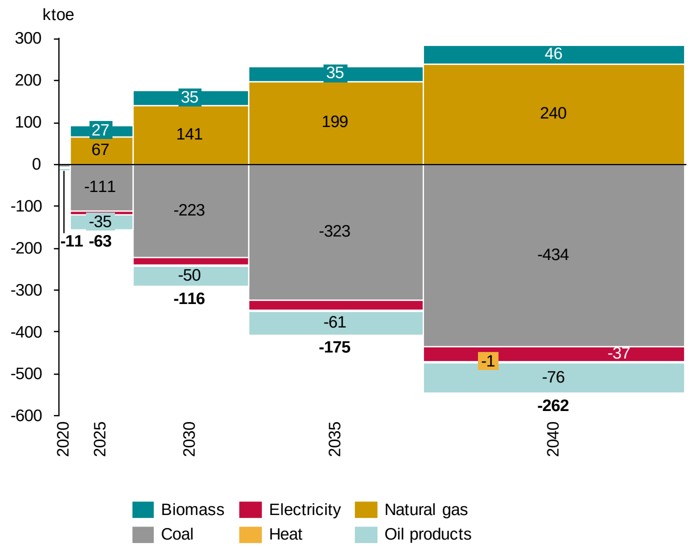
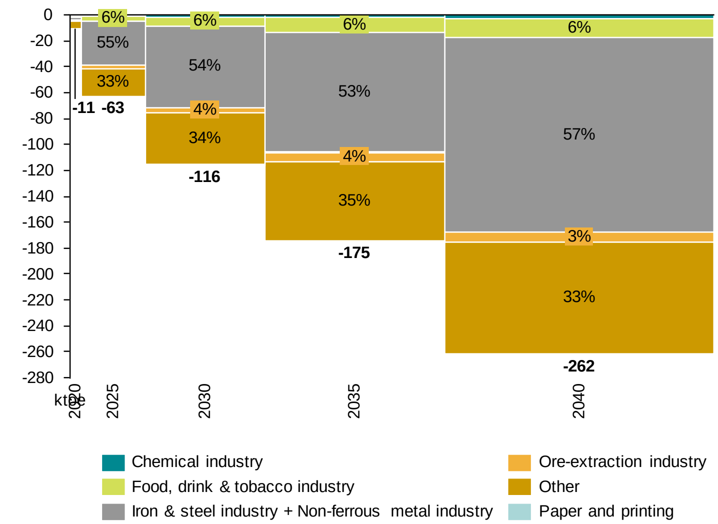
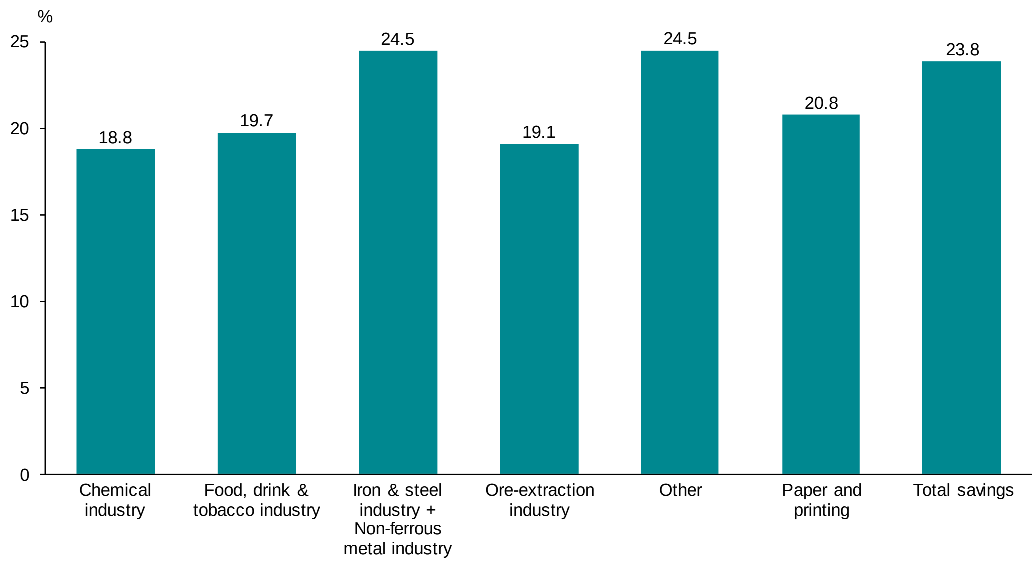


Figure 34. Final energy consumption savings by industry branches (ktoe)



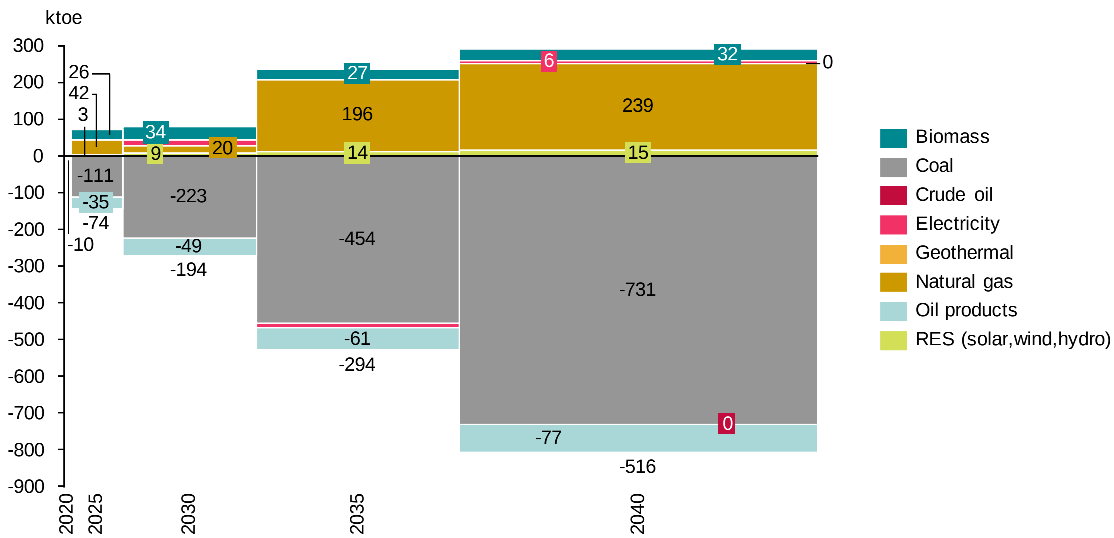
Note: the savings in 2030 are around 11 ktoe;

Figure 35. Reduction of energy consumption by industry branches (%)



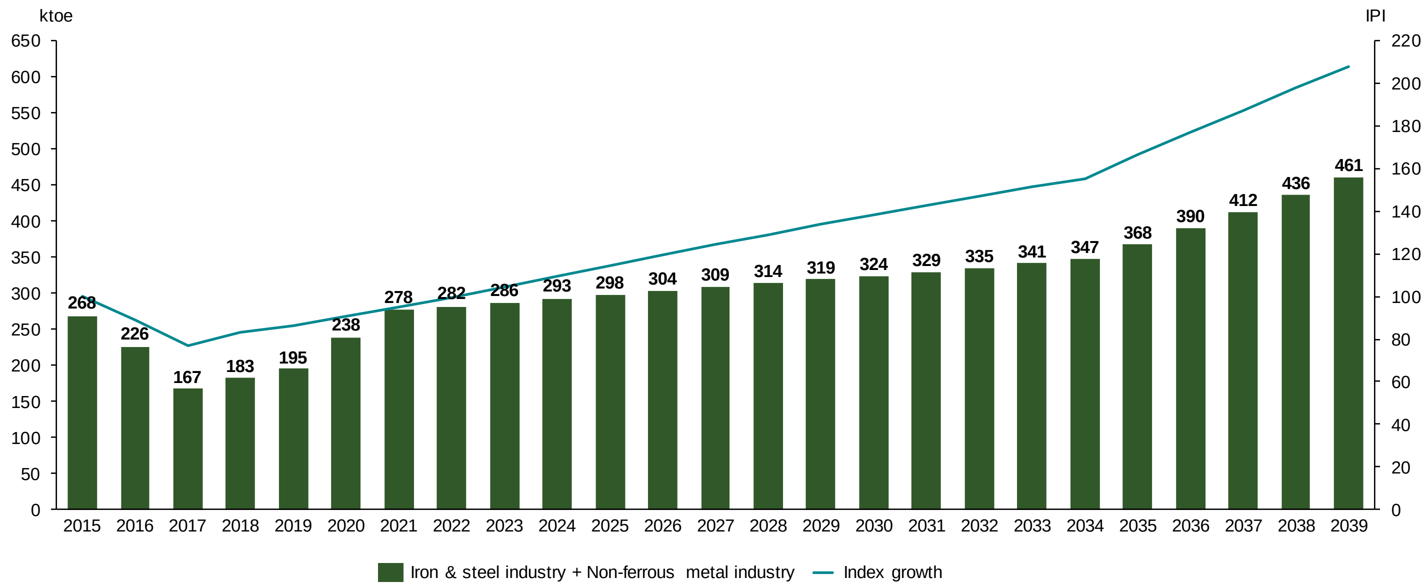
As a result of the reduction in electricity consumption, the consumption of primary energy is also reduced, especially of the coal used for electricity production. In 2040, primary energy savings are about 520 ktoe (7%), compared to the WOM scenario (Figure 36).

Figure 36. Primary energy savings (ktoe)



One of the main goals of this study is to ensure economic and industry development at reduced energy consumption, GHG and local emissions. With the implementation of the measures, exactly this goal is achieved. Figure 37 shows the process of decoupling of the industrial production index growth and energy consumption.

Figure 37. Energy consumption and industrial production index in the Iron and Steel Industry



As a result of the reduction in primary energy consumption, GHG emissions will also decrease. Cumulatively, in the period 2020-2040, total GHG emissions will be reduced by 20.429 ktCO2-eq (Figure 38), a decrease of 6.6% compared to the total cumulative GHG emissions in the WOM scenario. At yearly level, the total GHG emissions are mostly reduced in the period after 2030, when coal consumption begins to decline.

As a result of the implementation of the measures proposed in this study (Figure 39), in 2040 the GHG emissions compared to WOM scenario:

- from the Waste sector will decrease by 1.9%,
- from the Energy sector will decrease by 13.0%,
- the total GHG emissions will be reduced by 10.6%.

Figure 38. Cumulative reduction of the total GHG emissions by years (kt CO_2-eq)

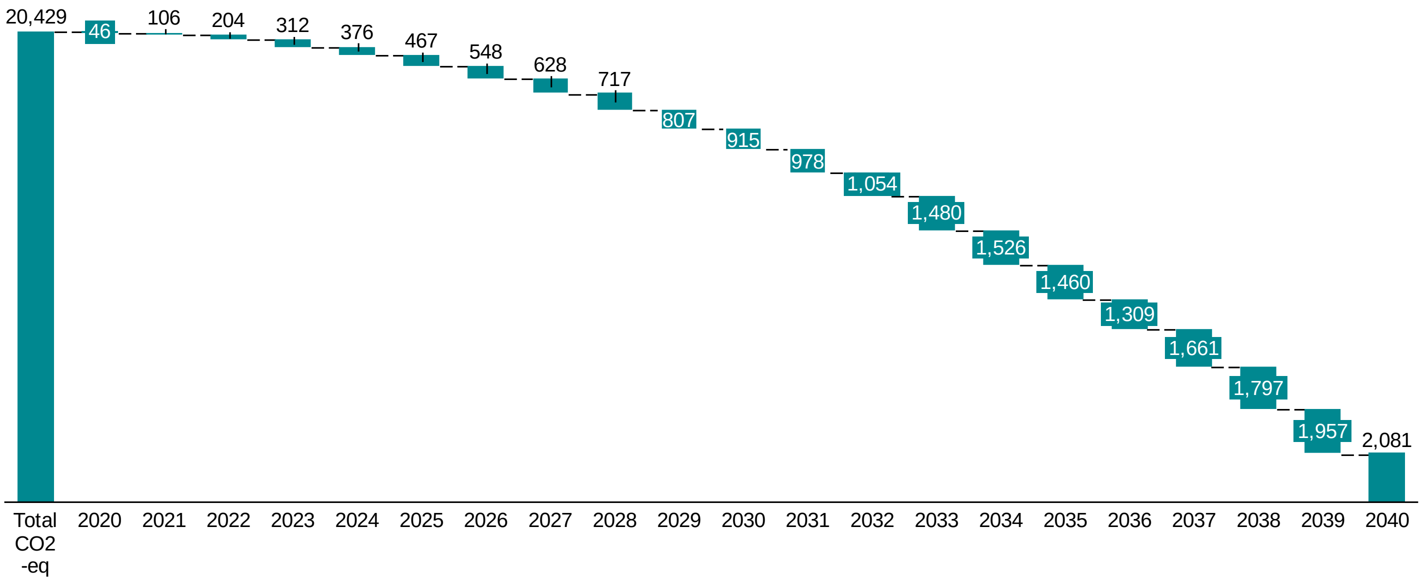
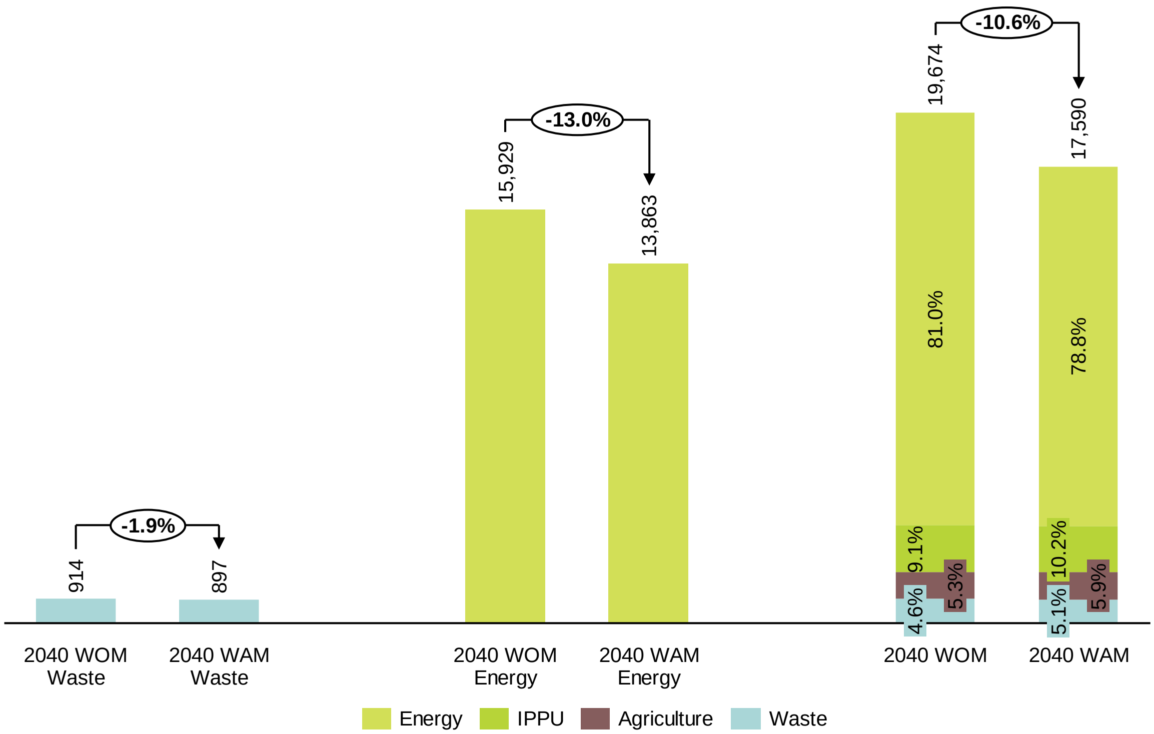
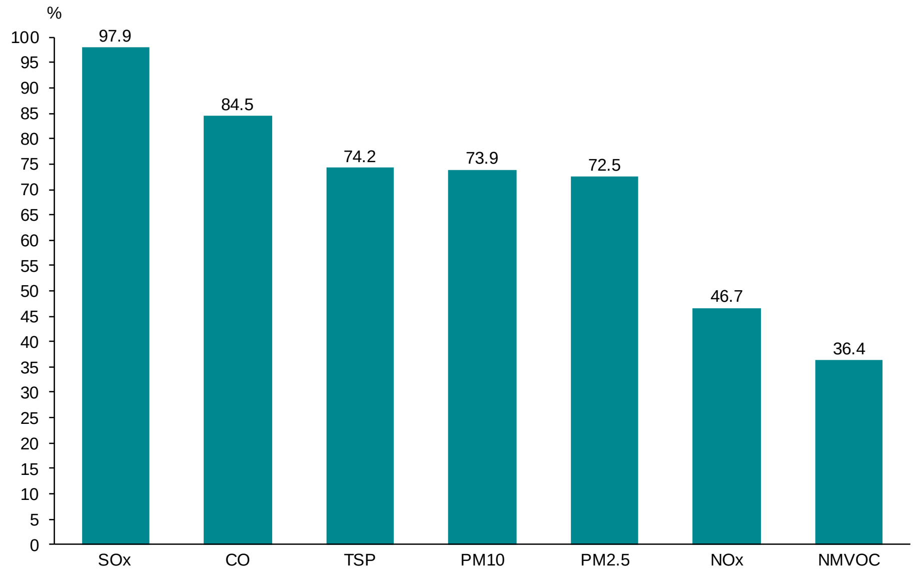


Figure 39. Comparison of the GHG emissions in WOM and WAM scenarios by sectors



The emissions of SO_x in the Industry are predominantly connected to the consumption of coal. Thus, by reducing the coal consumption to zero, the SO_x emissions from the Industry are reduced by about 98% (Figure 40). Additionally, for the same reason, there is a large decrease in CO and PM_{10} emissions by about 85% and 74%, respectively.

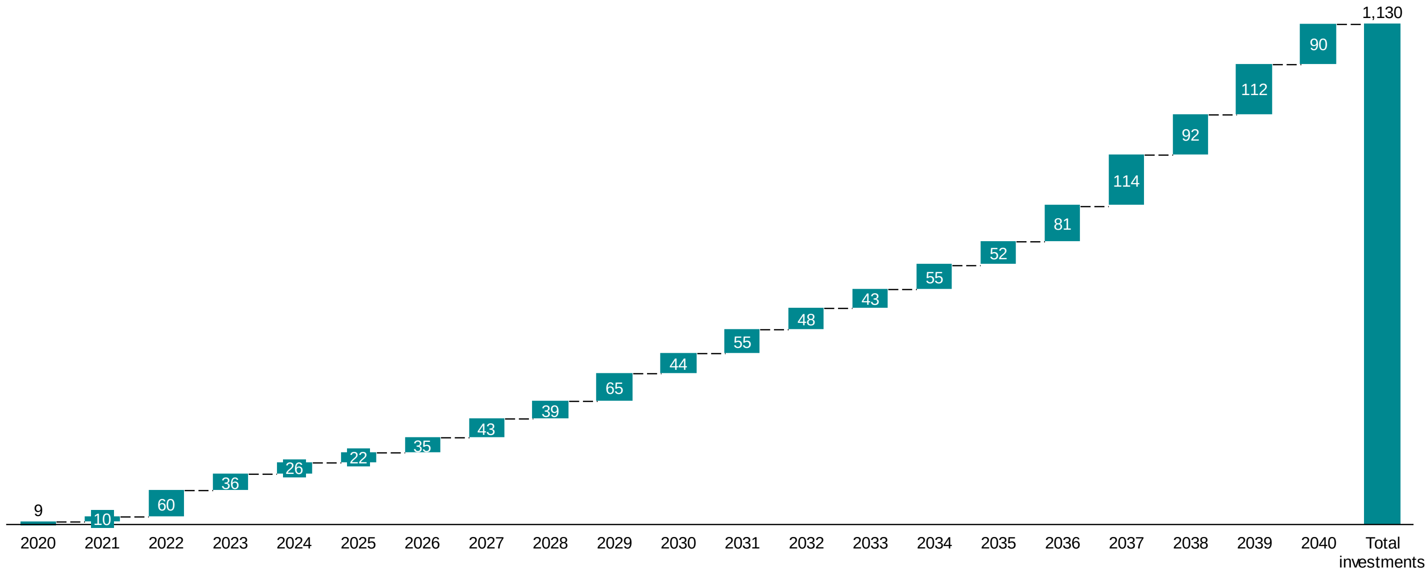
Figure 40. Reduction of local emissions from the Industry in the Energy sector (ktoe)



INVESTMENTS

More than one billion EUR is needed to implement this scenario (Figure 41). Most of the funds need to be invested after 2035 in order to replace the processes that use coal.

Figure 41. Total investments for the realization of the scenario and investments by years (mill. EUR)



CONCLUSION

This study provides an overview of the Industry in Macedonia, its role in the economy, energy consumption and greenhouse gas emissions. From the analysis of the current situation, it can be concluded that:

- The industry continuously increases its share in GDP and in 2017 participates with 21%;
- The Industry, which includes Construction (Other industries), contributes the most (49% in 2017) to the added value of the total Industry;
- From the total number of employees in Macedonia in 2018, about 30% are in the Industry, of which 36% are women;
- The Industry participated with 22% in the final energy consumption (of which 44% are in the Iron and Steel Industry) in 2018;
- In general, there is an improvement in terms of energy intensity (the process of decoupling of the energy consumption from the industrial production index) for each of the industry branches;
- GHG emissions from the Industry in all three sectors accounted for about 16.7% (10.3% Energy, 5.4% IPPU and 1% Waste) in total GHG emissions in 2016.

Since most of the emissions are from the Industry in the Energy sector, this study proposes 7 measures that will increase energy efficiency and the participation of renewable sources for electricity production in the Industry. Additionally, a measure has been proposed in the Waste sector for improved waste management in the Industry. All measures are aimed at improving the productivity of the companies at reduced energy consumption and thus reduced emissions. If the proposed measures are implements, the results show that compared to the WOM scenario in 2040:

- The final energy consumption of the Industry will be reduced by 24% (which is about 4 percentage points more compared to the results of TBUR, due to the introduction and analysis of additional measures in this study, such as Insulation, Lighting and Steam systems);
- Total GHG emissions will be reduced by 10.6%;
- GHG emissions from the Waste sector will decrease by 1.9%;
- GHG emissions from the Energy sector will decrease by 13%;
- From the local emissions, SO_x will be reduced by 98%;
- 1,130 mill. EUR is needed to implement the proposed measures.

Regarding the proposed measures, the main conclusion of this study is that first, within each of the companies, the ISO 50001 standard should be introduced, or regular energy audit should be implemented, especially in large enterprises. Based on this, goals should be set for each company individually and a series of measures should be taken to achieve them. When implementing the measures, it is recommended to start with the measures for which no or small investments are needed and the measures with the lowest risk, such as the Soft measures. These measures can often be ignored, as their individual effect may be small, but if implemented together, their potential is shown to reach up to 8% of the total reductions in GHG emissions from the proposed measures in the Industry. On the other hand, the biggest potential for reducing energy consumption, and thus GHG and local emissions, is the measure Process change and the introduction of CO_2 tax. As a result of these measures, the consumption of coal in the Industry is completely replaced by natural gas and renewable energy sources (waste biomass). However, the implementation of this measure is accompanied by large investments, and thus carries the biggest risk.

References:

- Electricity end uses, energy efficiency, and distributed energy resources baseline: Industrial Sector Chapter, Energy Analysis and Environmental Impacts Division Lawrence Berkeley National Laboratory, January 2017
- Greenhouse gas emission reductions enabled by products from the chemical industry, ECOFYS, March 2017
- 4 Top Industrial Energy Efficiency Solutions, Start-us Insights, https://www.startus-insights.com/innovators-guide/4-top-industrial-energy-efficiency-solutions/, Accessed on: 8/6/2020
- Decarbonization of industrial sectors: the next frontier, McKinsey&Company, June 2018
- Path to 2060: Decarbonizing the Industrial Sector, R. Duff, M.J. Lenox, December 2018
- Designing Industrial Strategy for a Low Carbon Transformation, Centre for Climate Change Economics and Policy, April 2017
- How to boost heavy industry's energy efficiency, J. Shah, January 2016
- Industrial Energy Efficiency: Designing Effective State Programs for the Industrial Sector, Industrial Energy Efficiency and Combined Heat and Power Working Group, March 2014
- Energy efficiency in industry: Different approaches for the same goals, D. Green, S. Cumberland, March 2019
- Low Carbon Technologies for Energy-Intensive Industries, Houses of Parliament, February 2012
- MOGUĆNOSTI INVESTIRANJA U MERE ENERGETSKE EFIKASNOSTI U SEKTORU ZGRADARSTVA I INDUSTRIJE, N. Tanasić
- Индустриска стратегија на Република Македонија 2018-2027, со Акциски план, Министерство за економија, Октомври 2018
- Low-carbon innovation for industrial sectors in developing countries, Policy brief, January 2014
- Energy efficiency for industry and appliances, Green Climate Fund
- A low-carbon path to enhanced industrial competitiveness, UNIDO ENERGY PROGRAMME, Industrial Energy Efficiency Unit, 2015
- Best Practices and Case Studies for Industrial Energy Efficiency Improvement, An Introduction for Policy Makers, Copenhagen Centre on Energy Efficiency, February 2016
- Energy Efficiency in Industry – potentials, trends and best practice from Germany, Mittelstand Global, October 2018

- STUDY ON ENERGY EFFICIENCY AND ENERGY SAVING POTENTIAL IN INDUSTRY AND ON POSSIBLE POLICY MECHANISMS, ICF Consulting Limited, December 2015
- Energy Efficiency Trends and Policies In Industry, An Analysis Based on the ODYSSEE and MURE Databases, September 2015
- Индустриска географија, Б. Апостоловска Тошевска, 2018
- Chapter 2: Lighting energy in buildings, GUIDEBOOK ON ENERGY EFFICIENT ELECTRIC LIGHTING FOR BUILDINGS, 2010